REPORT

of

THE EIGHTH INTERNATIONAL GEOGRAPHIC CONGRESS

HELD IN THE
UNITED STATES

1904

Edited by
The Committee on Printing

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

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ILLUSTRATIONS

PREFACE

In the following pages are given the history of the Eighth International Geographic Congress, its transactions, and the papers presented to it.

The Congress had 798 members, of whom 57 per cent were in attendance. As a Congress it traveled 1,500 miles and held meetings in six widely separated cities.

Two hundred and twenty papers were presented to the Congress, either in full, in abstract, or by title. Of these, 148 are here printed.

After the adjournment of the Congress in St. Louis, many of its members took part in an excursion to the Grand Cañon of the Colorado, in Arizona, and to the City of Mexico.

This report is printed by courtesy of the United States Congress, at the Government Printing Office. The joint resolution under which this is done was passed March 3, 1905, and reads as follows:

> *Resolved, etc.*, That the Public Printer be authorized and directed to print the report of the Eighth International Geographic Congress, held in the United States in September, 1904, the edition to consist of the usual number for the use of the Senate and House of Representatives, and 1,500 copies to be bound for the use of the Eighth International Geographic Congress.

HENRY GANNETT,
JAMES PAGE,
GILBERT H. GROSVENOR,
Committee on Printing.

REPORT

OF THE

EIGHTH INTERNATIONAL GEOGRAPHIC CONGRESS

HISTORY OF THE CONGRESS

As the report of the Eighth International Geographic Congress will no doubt fall into the hands of many who have not taken part in any preceding geographic congress, as well as of those members of this congress who were unable to attend its sessions, a few words as to the origin and progress of this congress may not prove uninteresting.

The First International Geographic Congress was held in the city of Antwerp, Belgium, from August 14 to 22, 1871. This congress served to stimulate the already reviving interest in the study of geography throughout Europe. The second congress convened in Paris in 1875, under the auspices of the Paris Geographical Society, whose president, M. Ferdinand de Lesseps, was president of the congress. Venice was the city of the third congress, in 1881. An international conference on geography, held in Paris in 1889 in connection with the exposition of that year, was adopted by the Paris Geographical Society as the Fourth International Geographic Congress. The fifth congress, held August 10 to 14, 1891, at Berne, Switzerland, decided that future geographic congresses should be held at intervals not less than three nor more than five years apart, and selected London as the meeting place for the sixth congress, and the time, July, 1895. The Seventh International Geographic Congress was held in the city of Berlin in August, 1899.

The events leading up to the selection of the United States as the country in which the Eighth International Geographic Congress should be held were as follows:

In 1895 Hon. Gardiner G. Hubbard, president of the National Geographic Society, Washington, D. C., at the instance of that society sent a formal invitation to the Sixth International Geographic Congress,

inviting the congress to hold its seventh meeting in the United States. The geographers of Germany invited the seventh congress to Berlin, and the latter invitation was accepted.

No formal invitation was extended to the Seventh International Geographic Congress by the American delegates. In fact, no formal or official invitation was received from any country. It was therefore decided by the congress to authorize the executive committee to accept any invitation which might be submitted after the adjournment of the congress.

At a meeting of the National Geographic Society on January 3, 1900, Prof. W J McGee, on behalf of a committee on the International Geographic Congress, submitted a report on the question of inviting the eighth congress to meet in this country. The report favored the project, and advised the enlistment of all the geographic societies of the country in the movement. It was adopted by the society.

In accordance with this action invitations to cooperate in the project were sent to the following societies: American Geographical Society of New York, Geographical Society of Philadelphia, Geographical Society of Baltimore, Geographical Society of Chicago, Appalachian Mountain Club, Geographical Society of the Pacific, Geographical Society of California, Geographical Society of Quebec, Geographical Society of Mexico, Sierra Club, Mazamas, American Alpine Club, and Peary Arctic Club.

Favorable replies having been received from several of these societies, the following letter, dated May 8, 1901, was addressed to Baron von Richthofen, president of the International Geographic Congress at Berlin:

SIR: In the name of the National Geographic Society, and on behalf of this and other geographic societies of the United States, I have the honor to tender to and through you, sir, a cordial invitation to the permanent committee of the geographic congress to convene the next congress in Washington, the national capital of the United States.

Should it please you, sir, and other members of the permanent committee to entertain this invitation I shall be glad to have it seconded formally by various institutions that have already signified their desire to welcome the International Geographic Congress to our national capital in cooperation with the National Geographic Society. Among these may be mentioned the Geographical Society of Philadelphia, the American Geographical Society of New York, the Geographical Society of Chicago, the Appalachian Mountain Club of Boston, and the Geographical Society of the Pacific of San Francisco.

A. GRAHAM BELL,
President National Geographic Society.

August 6, 1901, acceptance of the invitation was received by Dr. Bell. The letter of acceptance reads in part as follows:

MY DEAR SIR: The kind invitation tendered by you in the name of the society over which you preside, and in behalf of other geographic societies of the United

States, to convene the next International Geographic Congress in Washington, has been duly considered by the executive committee and will be thankfully accepted if sustained after deliberation with those other scientific bodies by which you desire the invitation to be seconded.

This answer to your letter of May 31 has been somewhat delayed because regard had to be taken of those invitations, as was intimated in an informal way during the last meeting of the congress. The conclusion arrived at is that the claim of the United States stands ahead of all others, because a formal invitation from there had already been tendered at the London meeting and is now reiterated.

There is indeed no place better fitted for geographers to assemble than Washington, the great center of scientific geographic exploration in America and the scientific workshop of a considerable number of eminent men.

BARON VON RICHTHOFEN.

Pursuant to the acceptance of this invitation, in November, 1902, a letter was sent to the several geographic societies asking that a representative be appointed by each to attend a meeting held in Washington for the purpose of making arrangements for the meeting of the Eighth International Geographic Congress.

Such a meeting was held, at which representatives from nearly all of the above-noted societies were present. A general discussion of the subject ensued, but no definite action was taken. Following this, on February 6, 1903, the president of the National Geographic Society was instructed to request each of the above societies to appoint one person as a member of a committee of arrangements for the Eighth International Geographic Congress. In response to this letter, a delegate was appointed from each society, with one or two exceptions only.

At a conference of the representatives of the several geographic societies in the United States, held at the American Geographical Society Building, New York City, June 20, 1903, a committee of arrangements was organized, having the same functions as the committee of organization of previous congresses. Each society was represented by one delegate. The officers and personnel of this committee are given on page 21.

The first question to decide was the time for holding the congress. After considerable correspondence with the most prominent geographers throughout the world, it was found that many of them had intended visiting America during the sessions of the Congress of Arts and Sciences to be held in connection with the exposition at St. Louis in the latter part of September, 1904. This, together with the climatic conditions and the fact that the college vacation terminated at the beginning of October, was the determining factor in selecting the early part of September as the time for the convening of the congress.

The next question was the place for holding the congress. Owing to the fact that the various host societies had their homes in widely separated cities, it was decided to make this a peripatetic congress, visiting several cities and holding sessions in each. A programme

was prepared, providing that the congress should open in Washington as the guest of the National Geographic Society; that after holding several sessions in the capital city it should be taken to Philadelphia, where it should be the guest of the Geographical Society of Philadelphia; next to New York, where it should be entertained by the American Geographical Society. On the way to Chicago it was planned to spend a day at Niagara Falls, a day was to be spent in Chicago with the Geographical Society of Chicago, and the closing sessions were to be held in St. Louis. After adjournment an excursion was planned to the Grand Canyon of the Colorado in Arizona and to the City of Mexico.

This programme was carried out as outlined. Between Washington and St. Louis the foreign delegates were, as to expense, the guests of the American societies. For the long excursion greatly reduced rates were obtained from the railways and the Pullman company.

Existing conditions made it impracticable to attempt any geographic exhibit of the same scope and character as the preceding ones. It was thought that the members of the congress would be more interested in visits to the several departments of the Government at Washington, where objects of geographic interest were to be found and methods employed in Government surveys could be observed, as well as in an inspection of the collections of geographic objects at the World's Fair in St. Louis. Inspections at these two cities therefore formed important features of the congress.

The committee of arrangements, having the same functions as the committee on organization in previous congresses, selected the officers for the congress, and through the following subcommittees perfected all the details for the meeting of the congress: Executive committee, committee on scientific programme, committee on finance, reception committee, transportation committee, committee on press, committee on badges, and committee on publications.

The executive committee was empowered to act for the committee of arrangements in such matters as were deemed important between meetings of the committee of arrangements.

Circumstances made it expedient to change the methods employed in former congresses for the selection of officers. The presidency had been too cumbersome, and for practical working purposes it was deemed proper to simplify the organization, especially in view of the fact that the congress was to move from one city to another. The active officers, therefore, consisted of the president of the congress, vice-presidents who might act as presiding officers at general sessions, the general secretary, and the chairmen and secretaries of sections.

A preliminary announcement was sent out in February, 1904, which recited the plans and purposes of the promoters of the congress and

ORGANIZATION

OFFICERS AND COMMITTEES

HONORARY PRESIDENT OF THE CONGRESS

THE PRESIDENT OF THE UNITED STATES

PRESIDENT

Commander ROBERT E. PEARY, U. S. Navy

HONORARY VICE-PRESIDENTS

Their excellencies: Comte Cassini, Russian ambassador; Señor Don Manuel de Azpíroz, Mexican ambassador; Baron Edmondo Mayor des Planches, Italian ambassador; Mr. Ladislaus Hengelmüller von Hengervár, ambassador from Austria-Hungary; Mr. J. J. Jusserand, ambassador from France; Freiherr Speck von Sternburg, German ambassador; The Right Honorable Sir H. M. Durand, ambassador from Great Britain; Mr. A. Grip, minister from Sweden and Norway; Señor Don Antonio Lazo Arriaga, minister from Guatemala; Mr. Constantin Brun, minister from Denmark; Mr. J. N. Léger, minister from Haiti; Mr. J. F. de Assis-Brasil, minister from Brazil; Señor Don Joaquín Bernardo Calvo, minister from Costa Rica; Señor Don Luis F. Corea, minister from Nicaragua; Mr. Kogoro Takahira, minister from Japan; Mr. Manuel Alvarez Calderón, Peruvian minister; Señor Martín García Mérou, minister from Argentina; Baron Moncheur, Belgian minister; Phya Akharaj Varadhara, minister from Siam; Señor Don Joaquín Walker-Martínez, minister from Chile; Viscount de Alte, minister from Portugal; Señor Don Gonzalo de Quesada, minister from Cuba; Señor Don Emilio de Ojeda, minister from Spain; Mr. Rafael S. López, minister from Salvador; Señor Dr. Alfredo Baquerizo, minister from Ecuador; Mr. Fernand Du Martheray, minister from Switzerland; Sir Chentung Liang-Cheng, minister from China; Señor Dr. Eduardo Acevedo Díaz, minister from Uruguay; Señor Don Cecilio Báez, minister from Paraguay; Jonkheer R. de Marees van Swinderen, minister from the Netherlands; Señor Don Ignacio Calderón, Bolivian minister; Señor Don J. Domingo de Obaldía, minister from Panama; Chekib Bey, minister from Turkey; Morteza Khan, minister from Persia; Mr. Henry G. K. Heath, minister from the Dominican Republic; Mr. Teh Moo Sin, minister from Korea; Señor Don Augusto F. Pulido, Venezuelan minister; Dr. Tomas Herran, minister from Colombia. The presidents of previous international geographic congresses: Duca di Sermoneta, Venice, 1881; Nationalrath Dr. Gobat, Berne, 1891; Sir Clements R. Markham, London, 1895; Ferdinand Freiherr von Richthofen, Berlin, 1899. The presiding officers chosen by host societies: G. K. Gilbert, National Geographic Society; Henry G. Bryant, Geographical Society of Philadelphia; R. E. Peary, American Geographical Society; R. D. Salisbury, Geographical Society of Chicago.

GENERAL SECRETARY

HENRY GANNETT

ASSISTANT SECRETARY

JAMES PAGE

TREASURER

JOHN JOY EDSON

CHAIRMEN AND SECRETARIES OF SECTIONS

Section A: Physiography of the land.—W. M. Davis, chairman; Bailey Willis, secretary.

Section B: Volcanoes and earthquakes.—C. H. Hitchcock, chairman; E. O. Hovey, secretary.

Section C: Glaciers.—H. F. Reid, chairman; R. S. Tarr, secretary.

Section D: Oceanography.—Wm. Libbey, chairman; R. A. Harris, secretary.

Section E: Meteorology and terrestrial magnetism.—R. DeC. Ward, chairman; G. W. Littlehales, secretary.

Section F: Biogeography.—Angelo Heilprin, chairman; John W. Harshberger, secretary.

Section G: Anthropogeography.—W J McGee, chairman; Frederick Starr, secretary.

Section H: Geodesy and geographic technology.—J. F. Hayford, chairman; E. E. Hayden, secretary.

Section I: Explorations.—H. G. Bryant, chairman; H. L. Bridgman, secretary.

Section J: Economic geography and hydrology.—E. R. Johnson, chairman; C. W. Hall, secretary.

Section K: Educational geography.—C. R. Dryer, chairman; E. C. Jones, secretary.

Section L: Historical geography.—E. L. Stevenson, chairman; Gilbert H. Grosvenor, secretary.

COMMITTEES

Committee of arrangements.—W J McGee, National Geographic Society, chairman; Henry G. Bryant, Geographical Society of Philadelphia; George B. Shattuck, Geographical Society of Baltimore; A. Lawrence Rotch, Appalachian Mountain Club, Boston; Zonia Baber, Geographical Society of Chicago; George Davidson, Geographical Society of the Pacific, San Francisco; Frederick W. D'Evelyn, Geographical Society of California, San Francisco; John Muir, Sierra Club, San Francisco; Rodney L. Glisan, Mazamas, Portland; Angelo Heilprin, American Alpine Club; Herbert L. Bridgman, Peary Arctic Club; William Morris Davis, Harvard Travelers' Club; J. H. McCormick, Secretary.

Finance committee.—John Joy Edson, chairman; David T. Day, Charles J. Bell.

Executive committee.—R. E. Peary, W J McGee, John Joy Edson, J. H. McCormick, W. M. Davis.

Committee on scientific program.—W. M. Davis, chairman; Angelo Heilprin, G. B. Shattuck, G. K. Gilbert, Henry Gannett, H. G. Bryant, R. E. Dodge, Cyrus C. Adams, William Libbey.

Transportation committee.—David T. Day.

Committee on press.—H. L. Bridgman.

COMMITTEES APPOINTED BY THE EIGHTH INTERNATIONAL GEOGRAPHIC CONGRESS

Standing committee.—Albrecht Penck, Vienna, chairman; W. M. Davis, Cambridge; Arthur de Claparède, Geneva; H. R. Mill, London; Henry Gannett, Washington.

List of members of the Eighth International Geographic Congress

[Members are numbered in order of registration.]

Name.	Address.	Member of—	Delegate from—
715. Aanesen, Capt. Edvard	Kristiania, Norway	Den Norske Turist Forening	Den Norske Turist Forening, Kristiania.
66. Abbe, Cleveland, jr	U. S. Geological Survey, Washington, D. C	National Geographic Society	
197. Adams, Chas. C	Ann Arbor, Mich	University of Michigan and National Geographic Society.	
600. Adams, Cyrus C	15 W. 81st st., New York, N. Y	National Geographic Society, American Geographical Society.	
324. Adler, Dr. Cyrus	1627 R st. NW., Washington, D. C	Smithsonian Institution and National Geographic Society.	
396. Aguiar, Col. F. M. de Sousa	Brazilian Commission, World's Fair, St. Louis, Mo.		
299. Albers, Hermann	Potsdamerstrasse 110, Berlin W., Germany		
245. Alexander, Albert	Kurfürstenstrasse 122, Berlin W., Germany		
617. Allen, Andrew H	Department of State, Washington, D. C	U. S. Board on Geographic Names	U. S. Board on Geographic Names.
320. Allen, Richard H	Chatham, Morris County, N. J		
44. Almeida, Prof. P. Camena d'	15 rue Villedieu, Bordeaux, France	University of Bordeaux	
586. Ambrose, H. T	100 E. Washington sq., New York, N. Y		
382. American Philosophical Society	104 S. 5th st., Philadelphia, Pa		
423. Ames, Oakes	North Easton, Mass	Harvard University	
249. Anderson, Professor Richard John.	Queen's College, Galway, Ireland	Natural History Museum, Queen's College, Connaught, Ireland.	
157. Angerer, Frank E	Care of Scarborough Co., 144 Essex st., Boston, Mass.		
706. Appert, Leopold	70 rue de Londres, Paris, France		
363. Arctowski, Henryk	103 rue Royale, Brussels, Belgium	Société Royale de Géographie d'Anvers	Société Royale de Géographie d'Anvers.
480. Arms, George A	Grand Hotel, Broadway and 31st st., New York, N. Y.	American Geographical Society	
239. Arriaga, Señor Don A. Lazo	30 Broad st., New York, N. Y		
582. Arrowsmith, Robert	100 E. Washington sq., New York, N. Y		
237. Aspremont, Count l'	Tour l'Aspremont, Beaumettes, Nice, Alpes Maritimes, France.	Real Società Geografica Italiana	Real Società Geografica Italiana.
707. Associação dos Engenheiros Civis Portuguezes.	Lisbon, Portugal		
19. Austin, O. P	1620 Massachusetts avenue, Washington, D. C	National Geographic Society	Bureau of Statistics.
679. Averett, Mary Judson	418 Central Park W., New York, N. Y	American Geographical Society	
687. Azpiazu, Don Ubaldo de	Instituto Geográfico, Madrid, Spain	Instituto Geográfico, Spain	Government of Spain.
356. Babb, Cyrus C	U. S Geological Survey, Washington, D. C	National Geographic Society	
302. Baber, Miss Zonia	University of Chicago, Chicago, Ill	National Geographic Society; University of Chicago.	Geographic Society of Chicago.
460. Bailey, Chas. B	175 State st., Portland, Me	National Geographic Society	
711. Baker, B. M	Y. M. C. A. Bldg., Baltimore, Md	do	
383. Baker, Dr. Frank	1728 Columbia road, Washington, D. C		
210. Baldwin, Wm. H	1709 21st st., Washington, D. C	National Geographic Society	
632. Ball, George Henry	Liverpool, England	Liverpool Geographical Society	Liverpool Geographical Society.

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324. Adler, Dr. Cyrus	1627 R st. NW., Washington, D. C	Smithsonian Institution and National Geographic Society.	
396. Aguiar, Col. F. M. de Sousa	Brazilian Commission, World's Fair, St. Louis, Mo.		
299. Albers, Hermann	Potsdamerstrasse 110, Berlin W., Germany		
245. Alexander, Albert	Kurfürstenstrasse 122, Berlin W., Germany		
617. Allen, Andrew H	Department of State, Washington, D. C	U. S. Board on Geographic Names	U. S. Board on Geographic Names.
320. Allen, Richard H	Chatham, Morris County, N. J		
44. Almeida, Prof. P. Camena d'	15 rue Villedieu, Bordeaux, France	University of Bordeaux	
586. Ambrose, H. T	100 E. Washington sq., New York, N. Y		
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249. Anderson, Professor Richard John.	Queen's College, Galway, Ireland	Natural History Museum, Queen's College, Connaught, Ireland.	
157. Angerer, Frank E	Care of Scarborough Co., 144 Essex st., Boston, Mass.		
706. Appert, Leopold	70 rue de Londres, Paris, France		
363. Arctowski, Henryk	103 rue Royale, Brussels, Belgium	Société Royale de Géographie d'Anvers	Société Royale de Géographie d'Anvers.
480. Arms, George A	Grand Hotel, Broadway and 31st st., New York, N. Y.	American Geographical Society	
239. Arriaga, Señor Don A. Lazo	30 Broad st., New York, N. Y		
582. Arrowsmith, Robert	100 E. Washington sq., New York, N. Y		
237. Aspremont, Count l'	Tour l'Aspremont, Beaumettes, Nice, Alpes Maritimes, France.	Real Società Geografica Italiana	Real Società Geografica Italiana.
707. Associação dos Engenheiros Civis Portuguezes.	Lisbon, Portugal		
19. Austin, O. P	1620 Massachusetts avenue, Washington, D. C	National Geographic Society	Bureau of Statistics.
679. Averett, Mary Judson	418 Central Park W., New York, N. Y	American Geographical Society	
687. Azpiazu, Don Ubaldo de	Instituto Geográfico, Madrid, Spain	Instituto Geográfico, Spain	Government of Spain.
356. Babb, Cyrus C	U. S Geological Survey, Washington, D. C	National Geographic Society	
302. Baber, Miss Zonia	University of Chicago, Chicago, Ill	National Geographic Society; University of Chicago.	Geographic Society of Chicago.
460. Bailey, Chas. B	175 State st., Portland, Me	National Geographic Society	
711. Baker, B. M	Y. M. C. A. Bldg., Baltimore, Md	do	
383. Baker, Dr. Frank	1728 Columbia road, Washington, D. C		
210. Baldwin, Wm. H	1709 21st st., Washington, D. C	National Geographic Society	
632. Ball, George Henry	Liverpool, England	Liverpool Geographical Society	Liverpool Geographical Society.

List of members of the Eighth International Geographic Congress—Continued

Name.	Address.	Member of—	Delegate from—
719. Botanical Society of Washington	Washington, D. C		
447. Boulenger, E. V	90 rue de la Gare, Roubaix, France	Société de Géographie de Lille	Aéro Club, Paris; Société de Géographie de Lille.
290. Boutwell, John Mason	U. S. Geological Survey, Washington, D. C	National Geographic Society	
399. Boyer, Prof. Paul	54 rue de Bourgogne, Paris, France	L'École des Langues Orientales	L'École des Langues Orientales.
483. Brackenridge, George W	San Antonio, Tex	Scientific Society, San Antonio	Scientific Society, San Antonio.
47. Brainard, Maj. David L., U.S. Army	Army Bldg., 39 Whitehall st., New York, N. Y.	American Geographical Society	
298. Brüm, Jacob	Engestrasse 130, Berne, Switzerland	Société de Géographie, Bern	
570. Branchi, Giovanni	Italian Pavilion, World's Fair, St. Louis, Mo		
195. Bratt, Melle. Maria	18 Scheeleg IV, Stockholm, Sweden		
147. Brewer, Wm. H	418 Orange st., New Haven, Conn	National Geographic Society; Arctic Club	Peary Arctic Club.
21. Bridgman, Herbert L	The Standard Union, Brooklyn, N. Y	American Geographical Society; National Geographic Society.	Peary Arctic Club.
287. Brigham, Prof. Albert Perry	Colgate University, Hamilton, N. Y	National Geographic Society	American Association for the Advancement of Science.
349. British Museum	Care of Dulau & Co., 37 Soho sq., London W., England.		
435 Britton, N. L	Bronx Park, New York, N. Y		
474. Broadhead, Prof. Garland C	Columbia, Mo	National Geographic Society	
14. Brooks, Alfred H	U. S. Geological Survey, Washington, D. C	do	
151. Brown, Jno. A. Harvie	Dunnipace House, Larbert, Stirlingshire, N. B.	Royal Geographical Society, Scotland	
293. Brown, Prof. Robt. Marshall	19 Elm st., Worcester, Mass	National Geographic Society; State Normal School, Massachusetts.	
451. Browne, Mrs. Alice Key	The Portland, Washington, D. C	National Geographic Society	
317. Brunhes, Prof. Jean	Int. Colonial Inst., Fribourg, Switzerland	Intercolonial Institute	
355. Brunialti, Prof. Attilio	19 via Virginio Orsini, Rome, Italy	Società Geografica Italiana	Società Geografica Italiana.
360. Brunialti, Giovanni	do	Italian Touring Club	Club Alpino Tridentino.
29. Bryant, Henry G	2013 Walnut st., Philadelphia, Pa	National Geographic Society; Geographical Society of Philadelphia.	Geographical Society of Philadelphia.
377. Burton, Prof. Alfred E	Massachusetts Institute of Technology, Boston, Mass.	National Geographic Society; Massachusetts Institute of Technology.	
218. Caillaud, Frédéric Romanet du	Isle Haute, Vienne, France	Société de Géographie de Paris	
362. Caix de St. Aymour, Robt. de	4225 Delmar boulevard, St. Louis, Mo	Société de Géographie Commerciale de Paris.	Société de Géographie Commerciale de Paris.
561. Calvo, Joaquin B	1329 18th st. NW., Washington, D. C.	National Geographic Society	
261. Campbell, Marius R	U. S. Geological Survey, Washington, D. C	Geological Survey	Geological Society of Washington.
572. Canadian Institute	Toronto, Canada		
577. Carl, Francis A	3847 West Pine boulevard, St. Louis, Mo		
550. Carleton, M. A	Bureau Plant Industry, U. S. Department of Agriculture, Washington, D. C.	National Geographic Society	
500. Carney, Prof. Frank	Granville, Ohio	Denison University	
461. Carpenter, Ford A	U. S. Weather Bureau, San Diego, Cal	National Geographic Society	
430. Carroll, Dr. James	Army Medical Museum, Washington, D. C	National Geographic Society; Army Medical Museum.	
374. Carvalho, Commodore José C. de	Rio Janeiro, Brazil		

155. Carvajal, M. Melliton	Lima, Peru	Sociedad Geográfica de Lima	
304. Cary, Mrs. Elizabeth M. L	184 Delaware ave., Buffalo, N. Y	National Geographic Society	
289. Cathen, Christian de	26 avenue de l'Alma, Paris, France	Société de Géographie de Paris	
688. Cattell, Prof. J. McK	Columbia University, New York, N. Y	National Geographic Society	
648. Chaille-Long, Col. Charles	2410 18th st., Washington, D. C	Société de Géographie de Paris	Société de Géographie de Paris.
234. Chalikiopoulos, Dr. Leonidas	Athens, Greece	Geographical Society of Athens	Geographical Society of Athens.
421. Chaney, Prof. L. W	717 2d st. E., Northfield, Minn	Minnesota Geographical Society	Minnesota Geographical Society.
13. Chapman, R. H.	U. S. Geological Survey, Washington, D. C	National Geographic Society	
576. Chase, R. D	U. S. Coast and Geodetic Survey, Washington, D. C.	Coast and Geodetic Survey	
573. Chavero, Alfredo	27 Avenida Madrid, Mexico, Mexico	National Geographic Society; Geographical Society of Mexico.	Government of Mexico.
366. Cheminais, M. G	21 rue La Paletier, Paris, France	Société de Géographie de Paris	
26. Chester, Rear-Admiral C. M	Naval Observatory, Washington, D. C	National Geographic Society	National Geographic Society; U. S. Navy.
265. Christen, T	Zweisimmen, Bern, Switzerland		
457. Cicalek, Dr. Theodor	Vienna, Austria	Société de Géographie, Vienna	Société de Géographie, Vienna.
130. Claparède, Arthur de	La Boisserette, Geneva, Switzerland	Geographical Society of Geneva	Geographical Society of Geneva; Government of Switzerland.
301. Clarke, Rev. Chas. Pickering	Holy Trinity Parsonage, Wimbledon, England		
158. Clarkson, Bauyer	26 W. 50th st., New York, N. Y	American Geographical Society	
574. Cleland, Frank Benedict	30 W. 44th st., New York, N. Y	National Geographic Society	
365. Cobb, Prof. Collier	University of North Carolina Chapel Hill, N. C	National Geographic Society; University of North Carolina.	University of North Carolina.
176. Coleman, Prof. A. P	School of Science, Toronto, Canada	National Geographic Society; Toronto University.	Toronto University.
288. Collesson, Pierre	47 rue des Clercelins, Nancy, France	Société de Géographie de l'Est	
473. Colvin, Verplanck	Box 1, Capitol Station, Albany, N. Y	American Geographical Society	Adirondack Survey.
57. Cook, Frederick A	670 Bushwick ave., Brooklyn, N. Y	National Geographic Society	Arctic Club.
346. Cordier, Prof. Henri	54 rue Nicolo (16), Paris, France	Société de Géographie; Société des Américanistes de Paris; Ministry of Public Instruction.	Ministry of Public Instruction; Société de Géographie; Société des Américanistes.
402. Corning, C. R	36 Wall st., New York, N. Y	American Geographical Society	
269. Cornwall, Arthur B	355 W. 118th st., New York, N. Y	National Geographic Society	
34. Corthell, E. L	1 Nassau st., New York, N. Y	do	
124. Coville, Frederick V	Department of Agriculture, Washington, D. C	do	
495. Coville, Miss Marion E	522 E. Washington st., Syracuse, N. Y		
658. Cowles, Prof. Henry C	University of Chicago, Chicago, Ill	Geographical Society of Chicago	
530. Crane, Charles R	31 W. 12th st., New York, N. Y	National Geographic Society; American Geographical Society.	
122. Credner, Rudolf	Greifswald, Germany	Geographische Gesellschaft zu Greifswald	Geographische Gesellschaft zu Greifswald.
224. Crosby, Oscar T	Metropolitan Club, Washington, D. C	National Geographic Society	
563. Crowell, John Franklin	2144 P st. NW., Washington, D. C	National Geographic Society; Bureau of Statistics; American Association for the Advancement of Science.	
254. Curtis, Geo. Carroll	64 Crawford st., Boston, Mass	National Geographic Society	Boston Scientific Society.
373. Dahne, Dr. Eugenio	Porto Alegre, Rio Grande, do Sul, Brazil		
215. Dainelli, Dr. Giotto	Piazza San Marco 2, Florence, Italy		
264. Danes, Dr. Tiri	Prague, Bohemia	Geographical Society of Prague	Geographical Society of Prague.
238. Davidson, Prof. George	419 California st., San Francisco, Cal	National Geographic Society; Geographical Society of the Pacific.	Geographical Society of the Pacific.
329. Davis, A. P	U. S. Geological Survey, Washington, D. C	National Geographic Society	

List of members of the Eighth International Geographic Congress—Continued

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438. Davis, Lewis Johnson	1411 Massachusetts ave., Washington, D. C.	National Geographic Society	
464. Davis, Mrs. Mary R. Gale	1001 Fairfield ave., Bridgeport, Conn	...do	
358. Davis, Miss Miriam	Gwernvale, Brecon road, Abergavenny, Scotland.	Royal Scottish Geographical Society	
11. Davis, Prof. William M	17 Francis st., Cambridge, Mass	National Geographic Society; Harvard Travelers' Club.	Harvard Travelers' Club.
496. Dawson, Miles M	11 Broadway, New York, N. Y	American Geographical Society	
8. Day, Dr. David T	U. S. Geological Survey, Washington, D. C	National Geographic Society	National Geographic Society.
560. De Agostini, Prof. Giovanni	10–14 via Novara, Rome, Italy	Istituto Geografico Italiano	
408. Dean, Charles Ray	Department of State, Washington, D. C.	National Geographic Society	Department of State.
107. Delebecque, André	35 boulevard des Tranchees, Geneva, Switzerland.		
252. Dessen, H. F	Orleans House, Orleans road, London, England.	Royal Geographical Society of London	
297. Deutsche Seewarte	Hamburg 9, Germany		
672. D'Evelyn, Dr. Frederick W	Phelan Bldg., San Francisco, Cal	Geographical Society of California	Geographical Society of California.
285. Diaz, Señor Dr. Eduardo Acevedo.	The Normandie, Washington, D. C		
184. Diederichs, Jean	Quai des Brotteaux 11, Lyon, France		
227. Diller, J. S	U. S. Geological Survey, Washington, D. C.	National Geographic Society	
585. Dillman, L. M	100 E. Washington sq., New York, N. Y		
593. Dodge, Prof. Richard E	15 W. 81st st., New York, N. Y	National Geographic Society; American Geographical Society.	American Geographical Society.
612. Donne, T. Edward	Hamilton Hotel, St. Louis, Mo		Government of New Zealand.
371. Dos Santos, José Americo	5234 Fairmount ave., St. Louis, Mo	Sociedade de Geographia do Rio de Janeiro.	Sociedade de Geographia do Rio de Janeiro.
226. Douglas, E. M	U. S. Geological Survey, Washington, D. C.	U. S. Geological Survey	
674. Douredoure, Bernard L	2203 Spring Garden st., Philadelphia, Pa	Geographical Society of Philadelphia	
415. Drude, Professor Dr. Oscar	Königlicher Botanischer Garten, Dresden, Germany.	Akademie der Naturforscher	Akademie der Naturforscher.
331. Dryer, Prof. Chas. Redway	Indiana State Normal School, Terre Haute, Ind.	American Association for the Advancement of Science, Section E.	American Association for the Advancement of Science.
168. Drygalski, Dr. Erich von	Leibnitzstrasse 15a II, Charlottenburg, Germany		
516. Duchauffour, Alfred	3 rue de la Terrasse, Paris, France		
494. Dudley, Prof. William R	Stanford University, California	National Geographic Society	
228. Du Fief, Prof. J	116 rue de la Limite, Brussels, Belgium	Société Royale Belge de Géographie	
87. Dutton, Maj. C. E., U. S. Army	Englewood, N. J	National Geographic Society	
410. Earlham College	Richmond, Ind		
513. Easton, Robert T. B	120 Broadway, New York, N. Y	American Geographical Society	
117. Ebeling, Dr. Max	Friedenstrasse 99, Berlin N. O. 18, Germany		
332. Edson, John Joy	Washington Loan and Trust Co., Washington, D. C.	National Geographic Society	
424. Eggers, Dr. Aug	Grand Forks, N. Dak	American Alpine Club	
142. Ehrenburg, Dr. Karl	Paradeplatz 4, Würzburg, Germany	Universität, Würzburg	
642. Elmore, Frederico Augusto	Lima, Peru		
257. Emerson, Prof. B. K	Amherst, Mass	National Geographic Society	
93. Emmons, S. F	U. S. Geological Survey, Washington, D. C.	...do	

868. Erödi, Dr. Béla	Budapest, Hungary	Hungarian Geographical Society	Hungarian Geographical Society and Government, Hungary.
848. Estien, Marcel	3629 Lindel boulevard, St. Louis, Mo.		
676. Estrada, E. Duque	Habana, Cuba		
669. Fairbanks, Harold W	Berkeley, Cal		
838. Fairleigh, David W	Louisville Trust Bldg., Louisville, Ky	Filson Club	Filson Club.
60. Falk, Th	15 rue du Parchemin, Brussels, Belgium		
99. Farnham, Amos Wm	141 W. 4th st.; Oswego, N. Y	National Geographic Society	Oswego State Normal School.
867. Fay, Charles E	Tufts Colleges, Mass	American Alpine Club	
588. Fenneman, Prof. N. M	Madison, Wis	National Geographic Society	
844. Fewkes, J. Walter	Forest Glen, Md	Bureau of American Ethnology	Bureau of American Ethnology.
258. Field, Wm. L. W	Canton ave., Milton, Mass	National Geographic Society	
468. Fischer, E. G	U. S. Coast and Geodetic Survey, Washington, D. C.	do	
434. Fischer, Dr. Emil S	3516 Morgan st., St. Louis, Mo	Imperial Royal Geographical Society of Austria.	Imperial Royal Geographical Society of Austria.
159. Fischer, Heinrich	Hasenhaide 73, Berlin S. 59, Germany	Gesellschaft für Erdkunde zu Berlin	Gesellschaft für Erdkunde zu Berlin.
182. Fischer, Professor Dr. Theobald	Lutherstrasse 10, Marburg, Germany		
282. Flahault, Charles	Université de Montpellier, Montpellier, France	Société Languedocienne de Géographie	Université de Montpellier, Annales de Géographie; Société Languedocienne de Géographie.
206. Flanagan, Rev. James	162 Erlanger road, New Cross, London S. E., England.	Manchester Geographical Society	Hull Young Men's West African Missionary Society.
59. Flemer, J. A	Norma, Va	National Geographic Society	
498. Fletcher, Dr. Robert	Hanover, N. H	do	
548. Ford, Jos. R	908 N. Calvert st., Baltimore, Md		
468. Foster, Miss Ellen B	1402 Binney st., Washington, D. C	National Geographic Society	
476. Fox, Royal E	P. O. Box 353, Syracuse, N. Y	National Geographic Society	
633. Fox, Williams C	2 Jackson place, Washington, D. C	International Bureau of the American Republics.	International Bureau of American Republics.
114. Friederichsen, Dr. Max	Hainholzweg 24, Göttingen, Germany	Geographisches Institut der Universität Göttingen.	Geographisches Institut der Universität, Göttingen.
514. Frisby, Prof. Edgar	1607 31st st., Washington, D. C	National Geographic Society	
467. Froidevaux, Henri	47 rue d'Angivillers, Versailles, France	Société de Géographie de Versailles	
370. Fschirkoff, Professor Dr. Anastas	Uliza Aksakoff 17, Sofia, Bulgaria		
361. Fuller, Albert H	60 Main st., Brockton, Mass		
208. Fuller, Myron L	U. S. Geological Survey, Washington, D. C	National Geographic Society	
604. Gallois, Lucien	59 rue Claude Bernard, Paris, France	Université de Paris	
156. Gambino, Prof. Giuseppe	Via Bandiera 34, Palermo, Italy	Real Società Geografica Italiana	Real Società Geografica Italiana.
16. Gannett, Henry	U. S. Geological Survey, Washington, D. C	National Geographic Society	Geological Survey; National Geographic Society.
540. Garland, Alejandro	Lima, Peru	Geographical Society of Lima	Geographical Society of Lima; Government of Peru.
603. Garrett, Robert	10 W. Saratoga st., Baltimore, Md		
45. Gauthiot, Charles	8 rue de Tournon, Paris, France	Société de Géographie Commerciale de Paris.	Société de Géographie Commerciale de Paris.
39. Genthe, Dr. Martha Krug	24 Sumner st., Hartford, Conn	National Geographic Society	
546. Geographische Gesellschaft	Lübeck, Germany		
445. Geographische Gesellschaft	Neuerwall 61, Hamburg, Germany		
616. Geographical Society of Minnesota.	Care of C. W. Hall, president University of Minnesota, Minneapolis, Minn.		
675. Gerassimov, Alexander	Wassili Ostrow, St. Petersburg, Russia		

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325. Gerbracht, E. W	American Sugar Refining Co., foot of S. 4th st., Brooklyn, E. D., N. Y.		
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126. Gibbons, Maj. Alfred St. Hill	Bude, North Cornwall, England	Royal Geographical Society of London	Royal Geographical Society of London.
12. Gilbert, G. K	U. S. Geological Survey, Washington, D. C	National Geographic Society	National Geographic Society.
526. Gill, Theo. N	Cosmos Club, Washington, D. C	Entomological Society	Entomological Society.
64. Gilman, Daniel C	Johns Hopkins University, Baltimore, Md	Geographical Society of Baltimore	Geographical Society of Baltimore; National Geographic Society.
76. Girard, Jules	10 rue Bossuet, Paris, France	Société de Géographie de Paris	
190. Glenn, Prof. Leonidas C	Vanderbilt University, Nashville, Tenn	National Geographic Society	
32. Glisan, Rodney L	420 Chamber of Commerce Bldg., Portland, Oreg.	Mazamas	Mazamas.
537. Goan, Mrs. O. S	Hastings-on-Hudson, N. Y		
326. Goode, Prof. J. Paul	University of Chicago, Chicago, Ill	National Geographic Society	
270. Gordon, Prof. C. H	University Station, Seattle, Wash	do	
352. Gorman, Martin W	166 10th st., Portland, Oreg	Mazamas	
619. Goucher, Jno. F	Woman's College of Baltimore, Baltimore, Md.	National Geographic Society	
703. Graça, J. Cordeiro da	Rio de Janeiro, Brazil		
135. Grandidier, Guillaume	9 avenue Marceau, Paris, France	Société de Géographie de Paris	Société de Géographie de Paris; Government of France; Comité de Madagascar.
553. Gravelius, Professor Dr. H	13 Reissigerstrasse, Dresden, Germany		
219. Greely, Gen. A. W., U. S. Army	1914 G st., Washington, D. C	National Geographic Society	National Geographic Society.
337. Green, Pinckney F	Louisville Trust Bldg., Louisville, Ky	Filson Club	Filson Club.
584. Greene, J. A	100 East Washington sq., New York, N. Y		
106. Gregory, Prof. Herbert E	399 Yale Station, New Haven, Conn	National Geographic Society	
123. Greim, Professor Dr. Georg	Alicestrasse 19½, Darmstadt, Germany	Verein für Erdkunde zu Darmstadt	Verein für Erdkunde zu Darmstadt.
281. Grigoriew, Alexander	Suworowski prospect 31, St. Petersburg, Russia.	Imperial Royal Geographical Society Russia.	
420. Grinnell, George Bird	346 Broadway, New York, N. Y	National Geographic Society	
314. Groll, Dr. M	Georgenstrasse 34-36, Berlin N. W., Germany	Gesellschaft für Erdkunde zu Berlin	Geographische Gesellschaft, Bern.
7. Grosvenor, Prof. Edwin A	Amherst, Mass	National Geographic Society	
6. Grosvenor, Mrs. Gilbert H	1328 18th st., Washington, D. C	do	
5. Grosvenor, Gilbert H	do	do	
51. Gulliver, Frederic Putnam	St. Mark's School, Southboro, Mass	do	
295. Gunson, Wm. Telford	10 Marsden st., Manchester, Eng	Manchester Geographical Society	Manchester Geographical Society.
527. Gurtler, Prof. M	Tempelhafer Ufer 12, Berlin S. W. 61, Germany		
655. Haake, A. von	206 Hammond court, Washington, D. C	U. S. Board Geographic Names	U. S. Board Geographic Names.
645. Haddon, Alfred C	Inisfail, Hills road, Cambridge, Eng	Anthropological Institute	Anthropological Institute, London.
357. Hague, Arnold	1724 I st., Washington, D. C	National Geographic Society	
186. Hague, James D	18 Wall st., New York, N. Y	National Geographic Society; American Geographical Society.	
534. Haid, Dr. Matthaus	Stefanienstrasse 72, Karlsruhe, Baden, Germany	Technische Hochschule	Technische Hochschule.
611. Hale, Dr. William H	40 First place, Brooklyn, N. Y	American Association for the Advancement of Science, section E.	
568. Hall, Prof. Christopher W	University of Minnesota, Minneapolis, Minn	National Geographic Society	
386. Hall, James P	Tribune, New York, N. Y	American Geographical Society	

628. Hall, Samuel K	928 I st. NW., Washington, D. C	National Geographic Society	
575. Hall, W. Carvel	U. S. Geological Survey, Washington, D. C	....do	
283. Halvorsen, Oscar	Mining Bureau Manila, P. I	....do	Philippine Weather Bureau.
183. Hamm, Hermann	Lortzingstrasse 4, Osnabrück, Germany		
113. Hansen, Dr. Adolf	Loberstrasse 21, Giessen, Germany	Gesellschaft für Erdkunde und Volkskunde, Giessen.	Gesellschaft für Erdkunde und Volkskunde, Giessen.
327. Hanzlik Stanislaw	2017 I st., Washington, D. C		
650. Hardwick, S. H	1300 Pennsylvania ave., Washington, D. C	National Geographic Society	
340. Hare, J. Knowles	52 Macon st., Brooklyn, N. Y		
512. Harper, Roberts	P. O. Box 1733, Boston, Mass	Royal Geographical Society	
209. Harris, John Campbell	119 S. 16th st., Philadelphia, Pa	National Geographic Society	
503. Harris, R. A	U. S. Coast and Geodetic Survey, Washington, D. C.		
89. Harshberger, Prof. John W	737 Corinthian ave., Philadelphia, Pa	Geographical Society of Philadelphia	
700. Hartman, C. V	Carnegie Museum, Pittsburg, Pa	National Geographic Society	Carnegie Museum, Pittsburg.
63. Harvard College Library	Cambridge, Mass		
161. Hassert, Dr. Kurt	Vorgebirgsstrasse 31 II, Cologne, Germany	University of Commerce, Cologne	University of Commerce, Cologne.
351. Hawkins, Lester Leander	448 Sherlick Bldg., Portland, Oreg	National Geographic Society; Mazamas	
448. Hay, John, Hon	State Department, Washington, D. C	National Geographic Society	
24 0. Hayden, Lieut. Commander Edward Everett, U. S. Navy.	U. S. Naval Observatory, Washington, D. C	....do	U. S. Naval Observatory.
607. Hayford, John F	Coast Survey, Washington, D. C	Coast and Geodetic Survey	
262. Hayes, C. Willard	U. S. Geological Survey, Washington, D. C	Geological Survey	Geological Society of Washington.
294. Heichelheim, A	Giessen, Germany	Gesellschaft für Erdkunde und Volkskunde, Giessen.	
27. Heilprin, Prof. Angelo	Academy of Natural Sciences, Philadelphia, Pa	National Geographic Society; Geographical Society of Philadelphia.	American Alpine Club.
433. Hellmann, Professor Dr. Gustav	Margarethenstrasse 2, Berlin W, Germany	Gesellschaft für Erdkunde zu Berlin	
109. Helmolt, Dr. Hans F	Wasserturmstrasse 55, Leipzig, Germany	National Geographic Society	
394. Henry, Prof. A. J	Weather Bureau Washington, D. C	School of Geography; University, Oxford, England.	
102. Herbertson, A. J	University of Oxford, Oxford, England		
343. Herrick, Cheesman A	Central High School, Philadelphia, Pa	Geographical Society of Philadelphia	
170. Heurich, Christian	1307 New Hampshire ave., Washington, D. C	National Geographic Society	
640. Hill, Robert T	1738 Q. st., Washington, D. C	....do	
452. Hill, Dr. W. Scott	Augusta, Me	....do	
519. Hillers, J. K	238 1st st. SE., Washington, D. C		
581. Hinman, Russell	100 E. Wash. sq., New York, N. Y	National Geographic Society	
409. Hioki, Eki	1310 N st. NW., Washington, D. C	National Geographic Society; Tokio Geographical Society.	Tokio Geographical Society of Japan.
280. Hitchcock, Mrs. Charlotte E	Amherst, Mass		
160. Hitchcock, Prof. C. H	Dartmouth College, Hanover, N. H	National Geographic Society	
313. Hobbs, Prof. Wm. Herbert	University of Wisconsin, Madison, Wis	American Association for the Advancement of Science.	American Association for the Advancement of Science.
347. Hodges, Lieut. Commander H. M	Hydrographic Office, Navy Department, Washington, D. C.	Hydrographic Office, Navy Department	Hydrographic Office, Navy Department.
23. Hoe, Mrs. Arthur I	23 Apley court, Cambridge, Mass	National Geographic Society	
22. Hoe, Mrs. Robert	11 E. 36th st., New York, N. Y	....do	
597. Holbrook, Levi	15 W. 81st st., New York, N. Y	American Geographical Society	
150. Holden, Luther L	9 St. John st., Jamaica Plain, Mass	National Geographic Society	
481. Holmes, Miss Mary S	1331 N. 12th st., Philadelphia, Pa	National Geographic Society; Geographical Society of Philadelphia.	
453. Holt, H. P. R	The Gladstone, 1423 R st., Washington, D. C	National Geographic Society	

List of members of the Eighth International Geographic Congress—Continued

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714. Holway, Prof. Ruliff S	University of California, Berkeley, Cal	National Geographic Society; Geographic Society of the Pacific.	
387. Hopp, Franz	Andrassy ut 103, Budapest, Hungary	Hungarian Geographical Society	
485. Horsford, Miss Cornelia C. F	27 Craigie st., Cambridge, Mass	National Geographic Society	
334. Hotop, J. J	Thiererstrasse 68, Nieder-Jeutz, Germany	Deutsche Kolonial-Gesellschaft	
125. Hovey, Edmund Otis	American Museum of Natural History, New York, N. Y.	National Geographic Society	American Museum of Natural History.
36. Howe, Ernest	U. S. Geological Survey, Washington, D. C	U. S. Geological Survey	Harvard Travellers' Club.
499. Howell, Edwin E	612 17th st., Washington, D. C	National Geographic Society	
153. Hubbard, Prof. Geo. D	401 S. Aurora st., Ithaca, N. Y	do	
1. Hubbard, Mrs. Gardiner G	Twin Oaks, Washington, D. C	do	
456. Hubbard, Robert J	Cazenovia, N. Y	do	
414. Hunt, Chas. Warren	220 W. 57th st., New York, N. Y	American Society of Civil Engineers	
683. Huntington, Ellsworth	Milton, Mass	Harvard Travellers' Club	
596. Hurlbut, Geo. C	15 W. 81st st., New York, N. Y	American Geographical Society	
86. Hutcheson, David	Library of Congress, Washington, D. C	National Geographic Society	
622. Hutchison, Miss Jessie E	305 D st., NW., Washington, D. C	do	
248. Hyde, John	Bureau of Statistics, Department of Agriculture, Washington, D. C.	do	U. S. Department of Agriculture.
149. Instituto Geológico de México	Mexico, Mexico		
145. Istituto Idrografico della Regia Marina.	Genoa, Italy		
543. Jackson, John B	Care of U. S. Dispatch Agency, 4 Trafalgar sq., London, England.	National Geographic Society	
111. Janke, Col. Arthur	Martin Lutherstrasse 3, Berlin W. 30, Germany	Geographical Society of Metz	Geographical Society of Metz.
198. Jansen, Franz	Waterloo Ufer 17, Berlin S. W. 61, Germany	Kolonial-Gesellschaft zu Berlin	Kolonial-Gesellschaft zu Berlin.
88. Janson, Ernest N	802 Rhode Island ave., Washington, D. C	National Geographic Society	
193. Jefferson, J. P	Warren, Pa	do	
75. Jefferson, Prof. Mark S. A	State Normal School, Ypsilanti, Mich	do	
284. Jellett, Edwin C	118 Hermann st., Germantown, Philadelphia, Pa	Geographical Society of Philadelphia	
598. Jesup, Morris K	15 W. 81st st., New York, N. Y	National Geographic Society; American Geographical Society.	
292. Johnson, Prof. Emory R	University of Pennsylvania, Philadelphia, Pa.	National Geographic Society; Geographical Society of Philadelphia.	Geographical Society of Philadelphia.
477. Jones, Col. W. A., U. S. Army	20 Post-Office Bldg., Baltimore, Md	National Geographic Society	
342. Jordan, David Starr	Stanford University, California	National Geographic Society; Sierra Club.	Sierra Club; Stanford University.
653. Joubert, Emilio C	31 Broadway, New York, N. Y		Government of Dominican Republic.
191. Judd, Lieut. Col. E. D., U. S. Army.	Hartford, Conn	National Geographic Society	
579. Kan, Dr. C. M	University of Amsterdam, Amsterdam, Holland.		
25. Keach, Miss M. A	120 Congdon st., Providence, R. I	National Geographic Society	
49. Keltie, J. Scott	1 Savile row, London, England	Royal Geographical Society of London	Royal Geographical Society of London.
323. Kemp, Prof. James Furman	Columbia University, New York, N. Y	National Geographic Society; New York Academy of Science.	New York Academy of Science.
46. Kennedy, Dr. Geo. G	Readville, Mass	National Geographic Society	

28. Kennelly, Capt. David J	Louisburg, Cape Breton, Nova Scotia, Canada	Royal Geographical Society of London	Royal Geographical Society of London.
42. Kerr, Mark B	Stent, Cal	National Geographic Society	Sierra Club.
712. Keyser, R. Brent	14 E. Mt. Vernon place, Baltimore, Md		
682. Kienast, Prof. Dr. Herman	Schnürlingstrasse 37, Königsberg, Germany	Geographische Gesellschaft, Königsberg	Geographische Gesellschaft, Königsberg.
531. Kihlman, Dr. A. O	Korkeavnorenkatu 19, Helsingfors, Finland, Russia.	Department of Agriculture, Finland	
709. Kilvert, Maxwell A	Ortega 28, Mexico, Mexico	National Geographic Society	
412. King, George A	728 17th st., Washington, D. C	do	
539. Klotz, Otto Julius	487 Albert st., Ottawa, Canada	do	
481. Kohlman, Charles	1007 Madison ave., New York, N. Y	American Geographical Society	
178. Kollm, Capt. Georg	Wilhelmstrasse 23, Berlin S. W., Germany	Geographical Society of Berlin	Geographical Society of Berlin; German Geographical Association.
644. Königliche Landesuniversitäts Bibliothek.	Tübingen, Germany		
282. Kozloff, Capt. Petr. Kusmitch	Care of secretary Imperial Russian Geographical Society, St. Petersburg, Russia.	Imperial Royal Geographical Society	
422. Krahmann, Max	Weidendamm 1, Berlin N. W. 7, Germany		
250. Kremnitz, Major	San Fruttuoso, Torquay, England	Gesellschaft für Erdkunde zu Berlin	Gesellschaft für Erdkunde zu Berlin.
309. Krümmel, Doctor Prof. Otto	Niemannsweg 39, Kiel, Germany		
56. Kümmel, Henry B	Geological Survey of New Jersey, Trenton, N. J	Geological Survey of New Jersey	Geological Survey of New Jersey.
144. K. K. Militär-Geographisches Institut.	Landesgerichts-Strasse 7, Vienna VIII, Austria		
9. Kunz, Dr. George F	11-15 Union sq., New York, N. Y	New York Academy of Science	
328. Lacour, René	Banque Populaire, Cannes, France	Yacht Club de France; Société des Regates Cannaises.	Yacht Club de France; Société des Regates Cannaises.
69. Laflamme, Prof. J. C. K	Laval University, Quebec, Canada	Laval University, Quebec	
330. Larner, John B	1335 F st. NW., Washington, D. C	National Geographic Society	
165. La Section Topographique de l'État.	St. Petersburg, Russia		
266. Langheld, Wilhelm	Duala, Kamerun, West Africa		
416. Lawrence, E. A	27-29 W. 23d st., New York, N. Y	American Geographical Society	
230. Lawrence, Roswell B	Room 745, Tremont Bldg., 73 Tremont st., Boston, Mass.	Appalachian Mountain Club	
693. Le Boutillin, Dr. Theodore	2040 Chestnut street, Philadelphia, Pa	Geographical Society of Philadelphia	
462. Lecointe, Georges			
684. Leete, Chas. H	116 W. 59th st., New York, N. Y	American Geographical Society	
121. Levainville, Capt. J	14 rue Berlin, Angers, France	Société de Géographie de Paris	
175. Levasseur, Prof. E	Collège de France, Paris, France	Collège de France	
306. Leverett, Frank	Ann Arbor, Mich	National Geographic Society	
569. Liang-Cheng, Sir Chentung	2001 19th st. NW., Washington, D. C	do	Government of China.
80. Libbey, Prof. William	Princeton, N. J	American Geographical Society; National Geographic Society.	
708. Library of Congress	Washington, D. C		
670. Library, Free Public	Trenton, N. J		
419. Library, Hampton Institute	Hampton, Va		
163. Library of University of Toronto	Toronto, Canada		
62. Library, Public, of Boston	Boston, Mass		
720. Library of University of Illinois	Urbana, Ill		
178. Liddiard, James E	Rodborough Grange, Bournemouth, England	Royal Geographical Society and National Geographic Society.	
641. Lindgren, Waldemar	U. S. Geological Survey, Washington, D. C	U. S. Geological Survey	
279. Lionel-Marie, J	6 quai Debilly, Paris XVI, France	Société de Géographie de Paris	

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67. Little, George T.	Bowdoin College Library, Brunswick, Me.	Appalachian Mountain Club.	
217. Littlehales, G. W.	2132 Le Roy place, Washington, D. C.	National Geographic Society.	National Geographic Society.
510. Lobel, Mlle. Clémentine de	11 rue d'Edimbourg, Paris, France.	Société de Géographie de Paris.	
509. Lobel, Mlle. Jehane de	do	do	
507. Lobel, Loicq de	do	do	
508. Lobel, Mme. T. de	do	do	
137. d'Lóczy, Prof. D. Lewis	Budapest IV, Hungary	Geographisches Institut der Universität, Budapest.	Geographisches Institut der Universität Budapest.
312. Loewinson-Lessing, Doctor Prof. Franz.	Polytechnical Institute, Sosnowka, St. Petersburg, Russia.	Polytechnical Institute, St. Petersburg.	
391. Logan, Walter S	27 William st., New York, N. Y.	National Geographic Society.	
220. Loernon, J.	Caibarien, province of Santa Clara, Cuba.		
518. Lyman, Chas	1243 New Jersey ave. NW., Washington, D. C.	National Geographic Society.	U. S. Treasury Department.
143. Lyons, Capt. Geo. Henry	Survey Department, Cairo, Egypt.	Royal Geographical Society of London.	
242. MacCauley, Rev. Clay	Providence, R. I.	Asiatic Society of Japan.	Asiatic Society of Japan.
318. MacCurdy, George Grant	237 Church st., New Haven, Conn.	National Geographic Society; Yale University.	
207. Macdonald, Alexander C.	31 Queen st., Melbourne, Australia.	Royal Geographical Society of Australasia	
379. MacGonigle, Jno. N.	West Rutland, Vt.	National Geographic Society.	
397. Maitland, Virginia K.	Upsal Woods, Mt. Airy Station, Philadelphia, Pa.	Philadelphia Geographical Society	
608. Maldonado, Commander Roberto C.	Circulo Naval, Valparaiso, Chile.		Government of Chile.
74. Manderson, Brig. Gen. Chas. F.	Omaha, Nebr.	National Geographic Society.	
614. Marbut, Prof. Curtis F.	University of Missouri, Columbia, Mo.	do	
235. Marek, Professor Dr. Richard.	Scharbersbachgasse 46, Graz, Austria	Naturwissenschaftlicher Verein für Steiermark.	Naturwissenschaftlicher Verein für Steiermark.
169. Marcuse, Dr. Adolf	Wilhelmstrasse 5, Gross-Lichterfelde, Germany.	Gesellschaft für Erdkunde zu Berlin	Gesellschaft für Erdkunde zu Berlin.
278. Marcuse, Edgar.	Boulevard Haussmann 81, Paris VIII, France.		
260. Margerie, Emmanuel de.	44 rue de Fleurus, Paris, France.	Annales de Géographie.	
216. Marinelli, Doctor Prof. Olinto.	Piazza San Marco 2, Florence, Italy.	Istituto di Studi Superiori.	
606. Markham, George D.	4961 Berlin ave., St. Louis, Mo.		
10. Marques, Dr. Manuel Gonçalves.	180 rua do Campo do Ourique, Lisbon, Portugal.	Royal Geographical Society, Lisbon.	
678. Marsters, V. F	Columbia University, New York, N. Y.	National Geographic Society; American Association for the Advancement of Science.	
557. Martin, Prof. Daniel S.	756 Quincy st., Brooklyn, N. Y.	College for Women, Columbia, S. C.	
580. Martin, F. Oskar	Bureau of Soils, Department of Agriculture, Washington, D. C.	National Geographic Society.	
203. Martin, H. C	182 Great Clowes st., Broughton, Manchester, England.	Manchester Geographical Society.	Manchester Geographical Society.
134. Martonne, Prof. Emmanuel de.	19 rue Albert, Rennes, France.	Société Bretonne de Géographie, Lorient.	Société Bretonne de Géographie, Lorient.
255. Mata, Professor Dr. Mario de la	Alcalá 72 duplicado, Madrid, Spain	Universidad Central de Madrid.	Universidad Central de Madrid.
71. Matthes, François E	U. S. Geological Survey, Washington, D. C.	National Geographic Society.	

List of members of the Eighth International Geographic Congress—Continued

Name.	Address.	Member of—	Delegate from—
501. Newcomb, Prof. Simon	1620 P st. NW., Washington, D. C	National Geographic Society	
566. Newcomer, Waldo	105 W. Monument st., Baltimore, Md	Geographical Society of Baltimore	
442. Newell, Frederick H	U. S. Geological Survey, Washington, D. C	National Geographic Society	
133. Nicolle, Ernest	11 Square Rameau, Lille, France	Société de Géographie de Lille	Société de Géographie de Lille.
92. Niles, Prof. William H	Massachusetts Institute of Technology, Boston, Mass.	National Geographic Society	
578. Nixon, Dr. John Howard	314 St. Louis st., Springfield, Mo	do	
668. Nordenskjold, Dr. Otto	Upsala, Sweden		
696. Norton, Miss Alice	1305 Maple ave., Evanston, Ill	National Geographic Society; Geographical Society, Chicago.	
406. Norton, Prof. Wm. Harmon	Cornell College, Mount Vernon, Iowa	National Geographic Society	
515. Nott, Charles C	826 Connecticut ave., Washington, D. C		
482. Noyes, Isaac P	409 4th st. SE., Washington, D. C	National Geographic Society; Anthropological Society.	
629. Nuttall, Mrs. Zelia	Department of Anthropology, World's Fair, St. Louis, Mo.	Harvard University	
470. Oakes, Brig. Gen. James, U. S. Army.	The Portland, Washington, D. C	National Geographic Society	
236. Oberhummer, Professor Dr. Eugen.	Alserstrasse 28, Vienna IX, Austria	Kaiserlich Königliche Geographische Gesellschaft zu Wien.	Kaiserlich Königliche Geographische Gesellschaft zu Wien.
544. Ogden, Herbert G	U. S. Coast and Geodetic Survey, Washington, D. C.	National Geographic Society	
425. Ohman, August R	97 Warren st., New York, N. Y	National Geographic Society; American Geographical Society.	
615. Oldham, H. Yule	Kings College, Cambridge, England	Royal Geographical Society of London	Royal Geographical Society of London and Geographical Association.
524. Oliphant, F. H	507 W. 2d st., Oil City, Pa	National Geographic Society	
659. d'Ollone, Viscount	46 rue Hamelin, Paris XVI, France	Société de Géographie Commerciale de Paris.	
229. Olmsted, Frederick Law, jr	Brookline, Mass	National Geographic Society; Harvard Travellers' Club.	
376. Olmsted, Victor Hugo	Bureau Statistics, Department of Agriculture, Washington, D. C.	National Geographic Society	Bureau of Statistics, Department of Agriculture.
116. Olson, Ole Theodor	St. Andrews Terrace, Grimsby, England	Grimsby and District Naturalists' Society	Grimsby and District Naturalists' Society.
350. O'Neill, Mark	615 Chamber of Commerce, Portland, Oreg	Mazamas	
400. Oppel, Professor Dr. Alwin	Lübeckerstrasse 31, Bremen, Germany	Geographical Society of Bremen	Geographical Society of Bremen.
188. Ortmann, Dr. Arnold E	Carnegie Museum, Pittsburg, Pa	National Geographic Society	
441. Ortroy, Prof. Fernand Van	Ghent, Belgium		
171. Osselen, J. R. van	Oud Entrepôt, Amsterdam, Holland	Royal Dutch Geographical Society	
50. Owen, Miss Luela A	306 N. 9th st., St. Joseph, Mo	National Geographic Society	
634. Page, James	U. S. Hydrographic Office, Washington, D. C	do	
119. Pailhade, J. de Rey	18 rue St. Jacques, Toulouse, France	Société de Géographie de Toulouse	Société de Géographie de Toulouse.
605. Palmer, T. S	U. S. Department of Agriculture, Washington, D. C.	National Geographic Society	
401. Parish, Henry	52 Wall st., New York, N. Y	American Geographical Society	

90. Parker, Prof. Herschel C	Columbia University, New York, N. Y	National Geographic Society; Appalachian Mountain Club.	Appalachian Mountain Club.
664. Parsons, C. B	78-80 Broad st., New York, N. Y	Maritime Association	Maritime Association.
479. Parsons, Edward Taylor	118 2d st., San Francisco, Cal	National Geographic Society; Sierra Club, Mazamas.	
647. Patski, Col. Julius H., U. S. Army	3924 Walnut st., W. Philadelphia, Pa		
336. Pattenhausen, Prof. Bernhard	Reichenbachstrasse 53, Dresden A, Germany	Verein für Erdkunde, Dresden	Verein für Erdkunde, Dresden.
562. Pattersen, Miss Laura E	2352 N. Broad st., Philadelphia, Pa	National Geographic Society; Geographical Society of Philadelphia.	
613. Pavey, Frank D	32 Nassau st., New York, N. Y		Government of Ecuador.
549. Pavlow, Alexander W	Moscow, Russia	Haute École des Ingénieurs, Moscow	Haute École des Ingénieurs, Moscow
595. Peary, Commander Robert E., U. S. Navy.	Navy Department, Washington, D. C	National Geographic Society; American Geographical Society.	American Geographical Society.
571. Peet, Charles Emerson	Lewis Institute, Chicago, Ill	National Geographic Society; Geographical Society of Chicago.	Geographical Society of Chicago.
428. Peirce, Charles F	42 Hanover st., Lynn, Mass		
276. Pelleschi, Giovanni	Alsina 319, Buenos Ayres, Argentina	Instituto Geográfico Argentino; Royal Geographical Society of London.	
392. Pena, Col. Ángel Garcia	Mexico, Mexico	Geographical Exploring Commission of Mexico.	Government of Mexico.
335. Penck, Doctor Prof. Albrecht	Vienna, Austria	Verein der Geographen an der Universität.	Verein der Geographen an der Universität; Verein für Erförderung des Adriatischen Meeres.
558. Pentland, Andrew Watson	1330 18th st., Washington, D. C	National Geographic Society; Colonial Historical Society.	
393. Pérez, Fernando Ferrari	Mexico, Mexico	Geographical Exploring Commission	Government of Mexico.
319. Perigny, Comte Maurice de	Paris, France	Société de Géographie Commerciale de Paris.	Société de Géographie Commerciale de Paris.
446. Perkins, Frank Walley	U. S. Coast and Geodetic Survey, Washington, D. C.	National Geographic Society	
95. Perkins, Henry Cleveland	1701 Connecticut ave., Washington D. C	do	
565. Perrine, Miss Lura L	Valley City, N. Dak	American Association for the Advancement of Science.	
61. Pfeil und Klein Ellguth, Joachim Friedrich, Graf von.	Friedersdorf, Schlesien, Germany	Geographische Gesellschaft für Thüringia in Jena.	Geographische Gesellschaft für Thüringen in Jena.
636. Pforlte, Otto F	15 Donaldson ave., Rutherford, N. J	National Geographic Society	
82. Philippson, Professor Dr. Alfred	19 Moltkestrasse, Bonn, Germany	University of Bonn	
77. Pinchot, Gifford	U. S. Department of Agriculture, Washington, D. C.	National Geographic Society	
354. Pires, Antonio Olyntho dos Santos	Bello Horizonte, Minas Geraes, Brazil	Sociedade de Geographia do Rio de Janeiro.	Sociedade de Geographia do Rio de Janeiro.
378. Platt, Mary I	15 Davis ave., Brookline, Mass	Appalachian Mountain Club	Appalachian Mountain Club.
511. Pope, Dr. C. Augusta	163 Newbury st., Boston, Mass	National Geographic Society	
440. Pratt, Dr. Joseph Hyde	Chapel Hill, N. C	do	
73. Pratt, Col. R. H., U. S. Army	Superintendent Indian School, Carlisle, Pa	do	
85. Prosser, Prof. Charles S	Ohio State University, Columbus, Ohio	do	
139. Prowse, G. R. F	Brandon, Manitoba	Geographical Society of Philadelphia	
97. Pusey, F. S	Germantown, Philadelphia, Pa	do	Geographical Society of Philadelphia.
310. Putnam, G. R	Coast and Geodetic Survey, Washington, D. C	National Geographic Society; U. S. Coast and Geodetic Survey.	
98. Putnam, Harrington	404 Washington ave., Brooklyn, N. Y	American Alpine Club; Appalachian Mountain Club; Sierra Club.	

List of members of the Eighth International Geographic Congress—Continued

Name.	Address.	Member of—	Delegate from—
417. Pyne, M. Taylor	Princeton, N. J	American Geographical Society	
274. Quelle, Otto	Nordhausen a. H., Germany	Naturalists Society of Thüringen	Naturalists Society of Thüringen, Nordhausen.
181. Rabot, Charles	9 rue Edouard Detaille, Paris XVII, France	Société de Géographie de Paris	
602. Ragland, Fannie C	114 N. Harvie st., Richmond, Va		
43. Ramond Gontaud, Georges	18 rue Louis-Philippe, Neuilly-sur-Seine, près Paris, France.	Société de Spéléologie	
395. Rathbun, Richard	Smithsonian Institution, Washington, D. C	Smithsonian Institution	
54. Raveneau, Louis	76 rue d'Assas, Paris VI, France	Rédaction des Annales de Géographie	
643. Record, Mrs. Carrie L	State Normal School, Fredonia, N. Y	National Geographic Society	
24. Redfield, Miss Julia W	Miss Hall's School, Pittsfield, Mass	National Geographic Society	
194. Redfield, Wm. W	2637 Portland ave., Minneapolis, Minn	do	
204. Rees, Rev. Fred A	57 Edge Land, Stretford, Manchester, England	Manchester Geographical Society	Manchester Geographical Society.
380. Reid, Harry Fielding	Johns Hopkins University, Baltimore, Md	National Geographic Society	
490. Remsen, Ira	do	do	
716. Rhode Island College of Agriculture and Mechanic Arts.	Kingston, R. I		
180. Rice, Dr. A. Hamilton	389 Beacon st., Boston, Mass	Royal Geographical Society, London; National Geographic Society; Harvard Travellers' Club.	
35. Rice, William North	Wesleyan University, Middletown, Conn	National Geographic Society	
381. Richardson, Dr. Chas. H	Department of Geology, Dartmouth College, Hanover, N. H.	Dartmouth College	
552. Richter, Edward	5909 Horton place, St. Louis, Mo	National Geographic Society	
246. Richter, Max	Jagerstrasse 55, Berlin W., Germany	Gesellschaft für Erdkunde zu Berlin	
132. Richthofen, Ferd. Baron von	117 Kurfürstenstrasse, Berlin W., Germany	University of Berlin	
638. Ridgely, William B	Treasury Department, Washington, D. C	National Geographic Society	
303. Ries, Heinrich	Cornell University, Ithaca, N. Y	do	
567. Riggs, Lawrason	814 Cathedral st., Baltimore, Md	Geographical Society of Baltimore	Geographical Society of Baltimore.
201. Ritchie, John, jr	Box 2795, Boston, Mass	Appalachian Mountain Club	Appalachian Mountain Club.
172. Roberts, Ellis H	Treasury Department, Washington, D. C	National Geographic Society	
15. Roberts, William F	730 15th st. NW., Washington, D. C	do	
105. Rockhill, Hon. W. W	International Bureau of American Republics, Washington, D. C.	International Bureau of American Republics.	
41. Rockwood, Chas. G., jr	34 Bayard lane, Princeton, N. J	National Geographic Society	
525. Roddy, Prof. Harry Justin	First Pennsylvania State Normal School, Millersville, Pa.	do	
454. Rogers, Augustus	Kentucky School for the Deaf, Danville, Ky	do	
4. Rossati, Chev. Guido	Rome, Italy	National Geographic Society; Department of Agriculture and Commerce, Rome.	
65. Rotch, A. Lawrence	Hyde Park, Mass	National Geographic Society	Appalachian Mountain Club.
657. Russell, Col. Andrew H	Ordnance Office, War Department, Washington, D. C.	National Geographic Society; Ordnance Office, War Department.	U. S. Army.
70. Russell, Prof. Israel C	University of Michigan, Ann Arbor, Mich	National Geographic Society	

List of members of the Eighth International Geographic Congress—Continued

Name.	Address.	Member of—	Delegate from—
417. Pyne, M. Taylor	Princeton, N. J	American Geographical Society	
274. Quelle, Otto	Nordhausen a. H., Germany	Naturalists Society of Thüringen	Naturalists Society of Thüringen, Nordhausen.
181. Rabot, Charles	9 rue Edouard Detaille, Paris XVII, France	Société de Géographie de Paris	
602. Ragland, Fannie C	114 N. Harvie st., Richmond, Va		
43. Ramond Gontaud, Georges	18 rue Louis-Philippe, Neuilly-sur-Seine, près Paris, France.	Société de Spéléologie	
395. Rathbun, Richard	Smithsonian Institution, Washington, D. C	Smithsonian Institution	
54. Raveneau, Louis	76 rue d'Assas, Paris VI, France	Rédaction des Annales de Géographie	
643. Record, Mrs. Carrie L	State Normal School, Fredonia, N. Y	National Geographic Society	
24. Redfield, Miss Julia W	Miss Hall's School, Pittsfield, Mass	National Geographic Society	
194. Redfield, Wm. W	2637 Portland ave., Minneapolis, Minn	do	
204. Rees, Rev. Fred A	57 Edge Land, Stretford, Manchester, England	Manchester Geographical Society	Manchester Geographical Society.
380. Reid, Harry Fielding	Johns Hopkins University, Baltimore, Md	National Geographic Society	
490. Remsen, Ira	do	do	
716. Rhode Island College of Agriculture and Mechanic Arts.	Kingston, R. I		
180. Rice, Dr. A. Hamilton	389 Beacon st., Boston, Mass	Royal Geographical Society, London; National Geographic Society; Harvard Travellers' Club.	
35. Rice, William North	Wesleyan University, Middletown, Conn	National Geographic Society	
381. Richardson, Dr. Chas. H	Department of Geology, Dartmouth College, Hanover, N. H.	Dartmouth College	
552. Richter, Edward	5909 Horton place, St. Louis, Mo	National Geographic Society	
246. Richter, Max	Jagerstrasse 55, Berlin W., Germany	Gesellschaft für Erdkunde zu Berlin	
132. Richthofen, Ferd. Baron von	117 Kurfürstenstrasse, Berlin W., Germany	University of Berlin	
638. Ridgely, William B	Treasury Department, Washington, D. C	National Geographic Society	
303. Ries, Heinrich	Cornell University, Ithaca, N. Y	do	
567. Riggs, Lawrason	814 Cathedral st., Baltimore, Md	Geographical Society of Baltimore	Geographical Society of Baltimore.
201. Ritchie, John, jr	Box 2795, Boston, Mass	Appalachian Mountain Club	Appalachian Mountain Club.
172. Roberts, Ellis H	Treasury Department, Washington, D. C	National Geographic Society	
15. Roberts, William F	730 15th st. NW., Washington, D. C	do	
105. Rockhill, Hon. W. W	International Bureau of American Republics, Washington, D. C.	International Bureau of American Republics.	
41. Rockwood, Chas. G., jr	34 Bayard lane, Princeton, N. J	National Geographic Society	
525. Roddy, Prof. Harry Justin	First Pennsylvania State Normal School, Millersville, Pa.	do	
454. Rogers, Augustus	Kentucky School for the Deaf, Danville, Ky	do	
4. Rossati, Chev. Guido	Rome, Italy	National Geographic Society; Department of Agriculture and Commerce, Rome.	
65. Rotch, A. Lawrence	Hyde Park, Mass	National Geographic Society	Appalachian Mountain Club.
657. Russell, Col. Andrew H	Ordnance Office, War Department, Washington, D. C.	National Geographic Society; Ordnance Office, War Department.	U. S. Army.
70. Russell, Prof. Israel C	University of Michigan, Ann Arbor, Mich	National Geographic Society	

192. Rutter, Frank R	Department of Agriculture, Washington, D. C.	National Geographic Society	
411. Salisbury, Prof. Rollin D	University of Chicago, Chicago, Ill	Geographical Society of Chicago	
300. Sampson, Alden	Haverford, Pa	National Geographic Society	
104. Sapper, Professor Dr. Carl	Olgastrasse 5, Tubingen, Germany		
697. Sarolea, Prof. Chas	Belgian consul, Chicago, Ill		
268. Saunders, Charles G	Rome, Italy	National Geographic Society; Appalachian Mountain Club.	
699. Saville, Prof. Marshall H	American Museum of Natural History, New York, N. Y.	American Museum of Natural History	
112. Schenck, Professor Dr. Adolf	7 Schillerstrasse, Halle a. S., Germany	Verein für Erdkunde in Halle	Verein für Erdkunde in Halle.
185. Schmidt, Prof. August	Hegelstrasse 32, Stuttgart, Germany	Württembergischer Verein für Handelsgeographie.	Württembergischer Verein für Handelsgeographie.
545. Schmidt, Prof. Nathaniel	Cornell University, Ithaca, N. Y	National Geographic Society; Cornell University.	
389. Schokalsky, Col. Jules de	Canal Catherine 144, St. Petersburg, Russia	Imperial Russian Geographical Society	
542. Schram, Dr. Robert	Staudgasse 1, Vienna, Austria	Kaiserlich Königliche Gradmessungs-Bureau.	
55. Schulmann, Dr. L	Residenzplatz, 16/11 Munich, Germany		
556. Scidmore, Eliza R	Care of U. S. consulate, Yokohama, Japan	National Geographic Society	
390. Scientific Society of San Antonio	San Antonio, Tex		
96. Seaver, Benjamin F	111 Pierrepont st., Brooklyn, N. Y	Appalachian Mountain Club	
33. Sedgwick, Lee M	Beals Bldg., Kansas City, Mo	National Geographic Society	
444. Selenka, Mrs. Margaretha	Care of Ernst Gerson, Kloster-Allee 80, Hamburg, Germany.	Geographische Gesellschaft, Munich	Geographische Gesellschaft, Munich.
81. Semple, Miss Ellen C	509 West Ormsby ave., Louisville, Ky	Filson Club	Filson Club.
243. Senckpiehl, Dr. R	Teltowerstrasse 5, Berlin S. W., Germany	Geographische Gesellschaft für Greifswald.	
492. Shattuck, Frederick C	Dark Harbor, Me	Anthropological Society	
686. Shattuck, Dr. George B	Johns Hopkins University, Baltimore, Md	Geographical Society of Baltimore	
652. Shaw, Dr. Hugh Thos	145 Upper Parliament, Liverpool, England		
491. Slaughter, Dr. B. Rosalie	1539 I st. NW., Washington, D. C	Anthropological Society	
403. Sloane, Charles S	Bureau of the Census, Department of Commerce and Labor, Washington, D. C.	Bureau of the Census	
78. Slocum, Dr. Chas. Elihu	Defiance College, Defiance, Ohio	National Geographic Society	Defiance College.
599. Smith, Dr. A. Donaldson	15 W. 81st st., New York, N. Y	American Geographical Society	
504. Smith, Dr. Andrew H	18 E. 46th st., New York, N. Y	National Geographic Society	
695. Smith, Miss Elizabeth	436 W. 67th st., Chicago, Ill	Geographical Society of Chicago	
497. Smith, Mrs. Emmeline L	19 Jansen ave., Chicago, Ill	National Geographic Society	
522. Smith, Geo. M	Care of Castaneda Hotel, Las Vegas, N. Mex	do	
222. Smith, George Otis	U. S. Geological Survey, Washington, D. C	do	
118. Smith, J. Fewson, sr	P. O. Box 431, Salt Lake City, Utah	do	
532. Smith, J. Russell	Wharton School, University of Pennsylvania, Philadelphia, Pa.	University of Pennsylvania	
618. Smith, Brig. Gen. Jos. R., U. S. Army.	2300 De Lancey st., Philadelphia, Pa	National Geographic Society	
316. Smith, Middleton	1616 19th st., Washington, D. C	National Geographic Society	Bureau of Statistics, Department of Agriculture.
484. Smith, T. W	616 E. Capitol st., Washington, D. C	do	
38. Smock, John C	Trenton, N. J	do	
439. Snyder, Dr. F. D	Ashtabula, Ohio	American Association for the Advancement of Science, Section E.	
405. Snyder, Prof. William H	125 Pennsylvania ave., Worcester, Mass	National Geographic Society	

List of members of the Eighth International Geographic Congress—Continued

Name.	Address.	Member of—	Delegate from—
241. Società Africana d'Italia	Naples, Italy		
120. Sociedade de Geographia de Lisboa.	Rua das Portas de Santo Antao, Lisbon, Portugal.		
651. Société de Géographie de l'Est	Nancy, France		
717. Société Impériale Russe de Géographie.	St. Petersburg, Russia		
131. Società Italiana di Esplorazioni Geografiche e Commerciali.	Milan, Italy		
154. Société Khédiviale de Géographie	Cairo, Egypt		
146. Sommerville, Prof. Maxwell	124 N. 7th st., Philadelphia, Pa	University of Pennsylvania	
489. Spencer, Dr. J. W	1718 21st st., Washington, D. C	Geological Society of America	
523. Squire, Willis C	1615 Chemical Bldg., St. Louis, Mo	National Geographic Society	
521. Squires, Grant	41 Wall st., New York, N. Y	National Geographic Society; Royal Geographical Society.	
541. Starr, Frederick	University of Chicago, Chicago, Ill	University of Chicago	Davenport Academy of Sciences.
502. Steffen, Dr. Hans	Casilla 1056, Santiago, Chile	Universidad de Chile	
129. Stephens, W. Hudson	Lowville, N. Y		
469. Stevens, W. M	Sioux City, Iowa	National Geographic Society	
591. Stevenson, E. L	15 W. 81st st., New York, N. Y	American Geographical Society	
321. Stevenson, Prof. John J	University Heights, New York, N. Y	National Geographic Society; New York Academy of Sciences.	New York Academy of Sciences.
202. Stienthal, Rev. S. A	16 St. Mary's Parsonage, Manchester, England	Manchester Geographical Society	Manchester Geographical Society.
673. Stokes, Frank Wilbert	3 N. Washington sq., New York, N. Y	Philadelphia Geographical Society	
660. Stose, George W	U. S. Geological Survey, Washington, D. C	U. S. Geological Survey	
263. Streuli, Rev. Arnold W. H	Lynwood, Whalley road, Manchester, England.	John Rylands Library	John Rylands Library, Manchester.
259. Stupart, R. F	Toronto, Canada	Meteorological Service, Canada	Meteorological Service, Canada.
84. Sugenheimer, S	333 H st., NE., Washington, D. C	National Geographic Society	
196. Sutton, J. R	P. O. Box 142, Kimberley, South Africa	Royal Meteorological Society	
718. Svambera, Dr. V	Prag II, 285, Austria		
475. Swartzell, G. W. F	B. H. Warner Co., 916 F st., Washington, D. C	Colonial Historical Society	
398. Swasey, Ambrose	Cleveland, Ohio	National Geographic Society	
488. Sweat, Mrs. Margaret J. M	103 Spring st., Portland, Me		
6. Swingle, Walter T	3315 17th st., NW., Washington, D. C	Bureau of Plant Industry	Bureau of Plant Industry, Department of Agriculture.
259. Szende, Julius	I, Christineuring 45 Budapest, Hungary	Société Hongroise de Géographie	
48. Tarr, Prof Ralph S	Cornell University, Ithaca, N. Y	National Geographic Society	
436. Taylor, Frank B	Fort Wayne, Ind	do	
698. Taylor, Genevieve	1305 Maple ave., Evanston, Ill	National Geographic Society; Geographical Society of Chicago.	
666. Telles, Dr. Silva	14 rua Saraiva Carvalho, Lisbon, Portugal	Sociedade de Geographia, Lisbon	
859. Tetzner, Dr. Franz	Leipzig, Germany		
583. Thalheimer, W. B	100 E. Washington sq., New York, N. Y		
704. Thompson, A. H	U. S. Geological Survey, Washington, D. C	National Geographic Society	
183. Thompson, Edwin Stanley	Wissinoming Hall, Mount Airy, Philadelphia, Pa.	National Geographic Society; Geographical Society of Philadelphia.	

375. Thompson, Dr. Oscar	Brazilian Pavilion, World's Fair, St. Louis, Mo.		
40. Thorndike, Townsend Wm	22 Newbury st., Boston, Mass	Harvard Travellers Club	
221. Thoroddsen, Prof. Thorvald	Rathsacksvej 1, Copenhagen, Denmark	Royal Geographical Society of Copenhagen.	Royal Geographical Society of Copenhagen.
110. Thoulet, Prof. T	Université de Nancy, Nancy, France	Université de Nancy	
384. Thurston, R. C. Ballard	Care of Ballard & Ballard Co., Louisville, Ky.		
713. Tiapkin Prof. Nicolai	Ingénieur-Hochschule, Pachmetjeuskaja 15, Moscow, Russia.	Ingénieur-Hochschule	
388. Tietze, Dr. Emil	Rasumoffskygasse 23, Vienna III, Austria	Imperial Geographical Society of Vienna.	Imperial Geographical Society of Vienna; Kaiserlich Königliche Geographische Gesellschaft in Wien.
177. Tittmann, O. H	U. S. Coast Survey, Washington, D. C.	National Geographic Society	National Geographic Society.
372. Todd, J. E	Vermilion, S. Dak	do	
710. Todd, Dr. Joe H	150 W. Liberty st., Wooster, Ohio	do	
53. Tolmatschow, J. P	Geological Museum, St. Petersburg, Russia	Geological Museum, Russia	
450. Torbert, John B	111 C st. SE., Washington, D. C	National Geographic Society	
162. Trinder, Henry William	Northbrook House, Bishops Waltham, Hants, England.	Royal Geographical Society, London	Royal Geographical Society, London.
83. Truesdell, George	Room 22, Wyatt Bldg., Washington, D. C.	National Geographic Society	
587. Tucker, Gilman H	100 E. Washington sq., New York, N. Y	do	
517. Tucker, H. St. George	1812 H st., Washington, D. C	National Geographic Society; George Washington University.	
58. University of Michigan	Ann Arbor, Mich.		
429. University of North Carolina	Library of University, Chapel Hill, N. C.		
590. Vail, H. H	100 E. Washington, sq., New York, N. Y		
211. Valle, Felipe	National Observatory, Tacubaya, Mexico	National Observatory, Mexico	National Observatory, Mexico.
529. Vargas, Eduardo M	P. O. Box 34, Irapuato, Guanajuato, Mexico		
667. Vasconcellos, Capt. Ernesto de	Lisbon, Portugal	Cartographic Committee of Portugal	Cartographic Committee of Portugal.
94. Vaux, George, jr	404 Girard Building, Philadelphia, Pa	National Geographic Society; Geographical Society of Philadelphia; Appalachian Mountain Club; American Alpine Club.	
845. Vavasseur, Baron R. de	17 rue François I, Paris, France		
646. Veatch, A. C	U. S. Geological Survey, Washington, D. C	U. S. Geological Survey	
478. Velain, Prof. Charles	Faculté des Sciences, Paris, France	Faculté des Sciences	
426. Verein für Erdkunde zu Dresden.	Dresden, Germany		
296. Verworn, Prof. Max	Hainholzweg 38, Gottingen, Germany	Geographische Gesellschaft für Thüringen.	Geographische Gesellschaft für Thüringen, Jena.
212. Vincent, Brig. Gen. Thos. M	1221 N st. NW., Washington, D. C	National Geographic Society	
241. Wagner, Dr. Eduard	Nürnbergerstrasse 46, Leipzig, Germany	Verein für Erdkunde zu Leipzig	
247. Wagner, Professor Dr. Hermann	Grünerweg 8, Göttingen, Germany	University of Göttingen	
17. Walcott, Chas. D	U. S. Geological Survey, Washington, D. C	National Geographic Society	National Geographic Society.
637. Waldeyer, Professor Dr. Wilhelm	Lutherstrasse 35, Berlin W., Germany	Gesellschaft für Erdkunde zu Berlin	
427. Walker, Gilbert T	Meteorological Office, Simla, British India	Meteorological Office, Simla	
407. Wallace, Dillon	15 William st., New York, N. Y	Arctic Club	Arctic Club.
103. Wallach, Henry	35 Cambridge st., Hyde Park, London W., England.	Royal Geographical Society of London	Geographical Society of Vienna.
311. Walter, Miss Emma	109 N. 16th st., Philadelphia, Pa	American Association for the Advancement of Science.	
100. Wanner, Theodor G	35 Koenigstrasse, Stuttgart, Germany	Württembergischer Verein für Handelsgeographie.	Württembergischer Verein für Handelsgeographie.
458. Wanner, Mrs. Theodor G	Stuttgart, Germany		

List of members of the Eighth International Geographic Congress—Continued

Name.	Address.	Member of—	Delegate from—
536. Ward, Mrs. Emma H	The Hamilton, Washington, D. C	National Geographic Society	
72. Ward, Prof. Robt. De Courcy	Harvard University, Cambridge, Mass	do	
455. Waring, Orville T	26 Broadway, New York, N. Y		
307. Warman, P. C	U. S. Geological Survey, Washington, D. C	National Geographic Society	
554. Waterhouse, Maj. Gen. James	Calcutta, India	Royal Geographical Society	
520. Watt, Miss Lila	Sunnay Acres, Guelph, Ontario, Canada	University of Toronto	University of Toronto, Canada.
625. Wedemeyer, Arnold J. D	Liberty, N. Y		
179. Weeks, F. B	U. S. Geological Survey, Washington, D. C	U. S. Geological Survey	
465. Weimer, Walter E	724 Cumberland st., Lebanon, Pa	National Geographic Society	
115. Werther, Capt. W	Magdeburgerstrasse 35, Berlin W., Germany	Deutscher Kolonial-Bund	Deutscher Kolonial-Bund.
404. Wetmore, Edmund	34 Pine st., New York, N. Y	American Geographical Society	
167. Wheeler, Arthur O	Calgary, Alberta, N. W. T., Canada	Royal Geographical Society	Topographical Survey; Department of the Interior, Canada.
689. Whitbeck, R. H	Trenton, N. J	National Geographic Society	
635. White, C. David	U. S. National Museum, Washington, D. C	U. S. Geological Survey	
315. White, James	Department Interior, Ottawa, Canada	National Geographic Society; Department of the Interior, Canada.	Department of the Interior, Canada.
538. Whitfield, R. P	American Museum of Natural History, New York, N. Y.	American Museum of National History	
437. Wilcox, Mrs. Aaron Morley	The Arlington, Washington, D. C	National Geographic Society	
143. Wilcox, Brig. Gen. Timothy E	1519 20th st. NW., Washington, D. C	do	
152. Willcox, Prof. Walter F	Cornell University, Ithaca, N. Y	do	
68. Williams, Talcott	916 Pine st., Philadelphia, Pa	do	
258. Willis, Bailey	U. S. Geological Survey, Washington, D. C	do	
37. Wilson, Prof. Alfred W. G	McGill University, Montreal, Canada	McGill University, Canada	
559. Wilson, Miss Alisan	The Lenox, Washington, D. C	National Geographic Society; American Association for the Advancement of Science.	
148. Wilson, Herbert M	U. S. Geological Survey, Washington, D. C	National Geographic Society	
547. Wilson, Mrs. Thomas	Rockledge Cottage, Haven, Me	do	
555. Winslow, Isaac O	Cottage City, Mass		
214. Winter, Dr. Ph	Dovenhof 23, Hamburg, Germany	Geographische Gesellschaft, Hamburg	
277. Witte, Emil	Freienwalde, Germany	Geographische Gesellschaft zu Breslau	
692. Wood, Herbert C	East High School, Cleveland, Ohio	National Geographic Society	
30. Wood, Walter	400 Chestnut st., Philadelphia, Pa	do	
631. Woods, Albert F	U. S. Department of Agriculture, Washington, D. C.	Bureau of Plant Industry	Bureau of Plant Industry, Department of Agriculture.
535. Woodward, R. S	Washington, D. C	Columbia University, New York	
127. Workman, Mrs. Fanny Bullock	Care of Messrs. Brown Shipley & Co., 123 Pall Mall, London, England.	Royal Geographical Society of London	
128. Workman, Wm. Hunter	do	do	
551. Wright, Carroll D	Worcester, Mass	National Geographic Society; International Statistical Association.	Bureau of Labor.
624. Wright, Mrs. Marie R	1313 Walnut st., Philadelphia, Pa		

101. Württembergischer Verein für Handelsgeographie.	Koenigstrasse 35, Stuttgart, Germany		
231. Wyckoff, Edward Guild	Cornell Heights, Ithaca, N. Y	American Geographical Society; Peary Arctic Club.	
639. Wygant, Miss Elsie A	University of Chicago, Chicago, Ill	University of Chicago	
601. Wyman, Dr. Walter	Butler Bldg., 3 B st. SE., Washington, D. C	National Geographic Society	Treasury Department.
291. Yamasaki, Naomasa	Haramachi 126, Koishikawa, Tokyo, Japan	Imperial University, Tokyo	
663. Yela, Dr. Joaquin	2 and 4 Stone st., New York, N. Y		Government of the Republic of Guatemala.
286. Zieten, Lieut. Col. von	Uhlandstrasse 31, Berlin W., Germany	Gesellschaft für Erdkunde zu Berlin	
273. Zimmerer, Dr. Heinrich	Schulstrasse 35, III, Ludwigshafen a. Rh., Germany.	Geographical Society of Munich	

List of associate members of the Eighth International Geographic Congress

Name.	Address.	Member of—
25. Alexander, Mrs. Albert	Kurfürstenstrasse 122, Berlin W., Germany.	
26. Alexander, Miss	do	
75. Arctowski, Madame	103 rue Royale, Brussels, Belgium.	
29. l'Aspremont, Countess	Tour l'Aspremont, Beaumettes, Nice, Alpes Maritimes, France.	
36. Bickmore, Mrs. Albert S.	120 W. 80th st., New York, N. Y.	
39. Bauer, Mrs. L. A	The Ontario, Washington, D. C.	
46. Carpenter, Mrs. Ford A	San Diego, Cal	National Geographic Society.
41. Chester, Mrs. C. M	Washington, D. C	
14. Claparède, Mrs. Arthur de	La Boisserette, Geneva, Switzerland.	Geographical Society of Geneva.
18. Clarkson, Mrs. Bauyer	26 W. 50th st., New York, N. Y.	
38. Cordier, Mme. Henri	54 rue Nicolo, Paris, France.	
1. Davis, Mrs. Ellen W	Cambridge, Mass	
48. Dawson, Mrs. Grace L	11 Broadway, New York, N. Y.	
30. Dessen, Mrs. H. T	Orleans House, Orleans road, London N., England.	
61. Devin, Aline Shane	1539 I st. NW., Washington, D. C.	
19. Diederichs, Mme. Jean	Quai des Brotteaux 11, Lyon, France.	
81. Dodge, Mrs. Stella D	417 W. 118th st., New York, N. Y.	
50. Duchauffour, Madame	Paris, France	
9. Dutton, Mrs. C. E	Morgan Park, Ill	

Name.	Address.	Member of—
55. Gannett, Miss Alice P	Bryn Mawr Club, New York.	
40. Gannett, Mrs. Henry	1829 Phelps place, Washington, D. C.	
77. Genthe, Mrs. Karl	Trinity College, Hartford, Conn.	Trinity College.
65. Golsh, Miss Flora	101 N. Broadway, Los Angeles, Cal.	
37. Hare, Mrs. J. Knowles	52 Macon st., Brooklyn, N. Y.	
49. Harris, Mrs. Emily J	U. S. Coast Survey, Washington D. C.	
23. Harris, Miss M	119 S. 16th st., Philadelphia, Pa.	
22. Harris, Mrs. S	do	
63. Hartman, Miss Sara	1313 Walnut st., Philadelphia, Pa.	
28. Hayden, Mrs. Ed. Everett	U. S. Naval Observatory, Washington, D. C.	
34. Heichelheim, Mrs. Aron	Giessen, Germany	
53. Hickey, Miss Susanna	1202 Q st. NW., Washington, D. C.	National Geographic Society.
64. Hieston, Mrs. Walter	New Willard, Washington, D. C.	Do.
60. Hinman, Caroline B	Summit, N. J	
35. Hotchkiss, Miss Caroline W.	32 Nassau st., New York, N. Y.	American Geographical Society.
13. Hovey, Mrs. Edmund O	115 W. 84th st., New York, N. Y.	National Geographic Society.
73. Hyde, Miss Edith E	1840 Summit ave., Washington, D. C.	
72. Hyde, Miss Elizabeth A	do	
71. Hyde, Mrs. John	do	

List of associate members of the Eighth International Geographic Congress—Continued

Name.	Address.	Member of—
74. Hyde, Miss M. Winifred	....do	
52. Kelton, Miss Mary E.	355 Pearl st., Burlington, Vt.	
80. Kirchwey, Miss Clara B.	Columbia University, New York, N. Y.	Columbia University.
4. Kümmel, Mrs. Henry B.	Trenton, N. J.	
32. Langheld, Gabriele	Nachodstrasse 17, Berlin W. 15, Germany.	
7. Libbey, Miss Elizabeth M.	Princeton, N. J.	
8. Libbey, Mrs. William	....do	
79. MacGregor, Miss Kate M.	Hillburn, N. Y.	Teacher's College.
17. Marcuse, Mrs. Adolf	Wilhelmstrasse 5, Gross-Lichterfelde, Germany.	
31. Mata, Madame de la	Madrid, Spain	
56. McCormick, Mrs. Aimee S.	The Stanton, Washington, D. C.	
57. McCormick, Miss Ruth M.	....do	
5. McDonald, Chas	421 10th st. NE., Washington, D. C.	National Geographic Society.
16. McLaren, James	Fort William, Ontario, Canada.	
6. Mell, Mrs. P. M	Clemson College, S. C.	
15. Mill, Mrs. Hugh Robt.	62 Camden square, London NW., England.	
20. Morgan, Mrs. S. Vaughan	37 Harrington Gardens, S. Kensington, England.	
33. Muirhead, Mrs. James	205 St. Vincent st., Glasgow, Scotland.	
78. Murray, Lady	Edinburgh, Scotland	
47. Oakes, Mrs. James	The Portland, Washington, D. C.	
3. Orr, Mrs. Florence O.	St. Joseph, Mo.	
62. Palmer, Miss Nellie F.	Fredonia, N. Y.	
59. Peary, Miss Marie A.	2014 12th st. NW., Washington, D. C.	
58. Peary, Mrs. Robt. E.	....do	
44. Peña, Angel Garcia	Jalapa, Veracruz, Mexico	
43. Peña, Miss Emma Garcia	....do	
42. Peña, Mrs. G. A. de Garcia	....do	
12. Pfeil, Countess Graf von	Schlesien, Germany	
66. Pringle, Mrs. M. A.	Yail, Selkirk, Scotland	
11. Pusey, Mrs. Della Fife	4603 Pulaski ave., Germantown, Philadelphia, Pa.	
51. Rice, Mrs. Wm. North	Middletown, Conn	
27. Richter, Mrs. Max	Jagerstrasse 55, Berlin W., Germany.	
21. Richie, Mrs. John, jr	581 Warren st., Roxbury, Mass.	Appalachian Mountain Club.
54. Smith, Mrs. Marie V. H.	1616 19th st., Washington, D. C.	
68. Swingle, Mrs. Walter T.	3315 17th st., Washington, D. C.	
2. Tarr, Mrs. Ralph S.	Ithaca, N. Y.	
24. Thoroddsen, Mrs. T.	Rathsacksvej 1, Copenhagen V., Denmark.	
10. Wanner, Mrs. Jessie	Stuttgart, Germany	
70. Waring, Miss Florence	26 Broadway, New York, N. Y.	
69. Waring, Miss Mary	....do	
67. White, Mrs. James	Ottawa, Canada	
76. Wilbur, Fedora Isabel	1719 15th st., Washington, D. C.	
45. Wilcox, Miss F. E.	1519 20th st. NW., Washington, D. C.	

Institutions represented at the Eighth International Geographic Congress, with their delegates

Institutions.	Delegates.
Adirondack Survey	Verplanck Colvin.
Akademie der Naturforscher, Germany	Dr. Oscar Drude.
Aéro Club, Paris, France	E. V. Boulenger.
American Alpine Club	Prof. Angelo Heilprin.
American Association for the Advancement of Science.	Prof. A. P. Brigham.
	Prof. C. R. Dryer.
	Prof. William H. Hobbs.
American Geographical Society	Prof. R. E. Dodge.
	Commander R. E. Peary.
American Museum of Natural History, New York, N. Y.	A. S. Bickmore.
	E. O. Hovey.
Annales de Géographie, Paris, France	Charles Flahault.
Anthropological Institution, London, England	A. C. Haddon.
Appalachian Mountain Club	Prof. H. C. Parker.
	Mary I. Platt.
	John Ritchie, jr.
	A. Lawrence Rotch.
Arctic Club	F. A. Cook.
	A. D. Wallace.
Asiatic Society of Japan	Rev. Clay MacCauley.
Boston Scientific Society, Boston, Mass	George C. Curtis.
Bureau of American Ethnology, Washington, D. C.	J. Walter Fewkes.
Bureau of Labor, Washington, D. C.	Carroll D. Wright.
Bureau of Plant Industry, Department of Agriculture, Washington, D. C.	W. T. Swingle.
	A. F. Woods.
Bureau of Statistics, Washington, D. C	O. P. Austin.
Bureau of Statistics, Department of Agriculture, Washington, D. C.	V. H. Olmsted.
	Middleton Smith.
Carnegie Museum, Pittsburg, Pa	C. V. Hartman.
Cartographic Committee of Portugal	Capt. Ernesto de Vasconcellos.
Club Alpino Tridentino, Italy	Giovanni Brunialti.
Davenport Academy of Sciences	Frederick Starr.
Defiance College, Defiance, Ohio	Dr. C. E. Slocum.
Department of the Interior, Canada	James White.
Deutscher Kolonial-Bund	Capt. W. Werther.
Entomological Society of Washington, D. C	Frank Benton.
	T. N. Gill.
Filson Club, Kentucky	D. W. Fanleigh.
	P. F. Green.
	Miss E. C. Semple.
Franklin Institute, Philadelphia, Pa	John Birkinbine.
General Land Office, Department of the Interior, Washington, D. C.	Frank Bond.
Geographic Names, Board on, Ottawa, Canada	Dr. Robert Bell.
Geographical Association, Oxford, England	H. Y. Oldham.
Geographical Society of Athens, Greece	Dr. Leonidas Chalikiopoulos.
Geographical Society of Baltimore, Md	D. C. Gilman.
	Lawrason Riggs.
Geographical Society of Berlin, Germany	Capt. Georg Kollm.
	Dr. Adolf Marcuse.
Geographical Society of Bremen Germany	Prof. Alwin Oppel.
Geographical Society of California	Dr. F. W. d'Evelyn.
Geographical Society of Chicago	Miss Zonia Baber.
	C. E. Peet.
Geographical Society of Geneva, Switzerland	Arthur de Claparède.
Geographical Society of Hungary	Dr. Bela Erödi.
Geographical Society of Lima, Peru	Alejandro Garland.
Geographical Society of Liverpool, England	G. H. Ball.
Geographical Society of Metz, Germany	Col. Arthur Janke.
Geographical Society of Munich, Germany	Mrs. Margaretha Selenka.
Geographical Society of the Pacific, California	Prof. George Davidson.
Geographical Society of Philadelphia, Pa	Amos Bonsall.
	H. G. Bryant.
	Prof. E. R. Johnson.
	F. S. Pusey.
Geographical Society of Prague, Bohemia	Dr. Tiri Danes.
Geographische Gesellschaft, Bern, Switzerland	Dr. M. Groll.
Geographische Gesellschaft, Greifswald, Germany	Rudolf Credner.
Geographische Gesellschaft, Königsberg, Germany	Dr. Herman Kienast.
Geographisches Gesellschaft für Thüringen in Jena, Germany.	Prof. Max Verworn.
	Graf von Pfeil.
Geographisches Institut der Universität, Budapest, Hungary.	Prof. D. L. d'Loczy.
Geographisches Institut, Göttingen, Germany	Dr. Max Friedrichsen.
Geological Society of Washington, D. C	M. R. Campbell.
	C. Willard Hayes.
Geological Survey of New Jersey	H. B. Kümmel.
Geological Survey, Ottawa, Canada	Dr. Robert Bell.
Geological Survey, Washington, D. C	Henry Gannett.
German Geographical Association	Rudolph Credner.
	Capt. Georg Kollm.
Gesellschaft für Erdkunde zu Berlin, Germany	Dr. Adolf Marcuse.
	Heinrich Fischer.
	Major Kremnitz.
Gesellschaft für Erdkunde und Volkskunde, Giessen, Germany.	Dr. Adolf Hansen.
Government of Chile	Commander R. C. Maldonado.
Government of China	Sir Chentung Liang-Cheng.
Government of Dominican Republic	E. C. Joubert.
Government of Ecuador	Frank D. Pavey.
Government of France	Guillaume Grandidier.
Government of Guatemala	Dr. Joaquin Yela.

Institutions represented at the Eighth International Geographic Congress, with their delegates—Continued

Institutions	Delegates
Government of Hungary	Dr. Bela Erodi
Government of Japan	Prof. T. Nasu
Government of Mexico	Alfredo Chavero.
	Col. A. G. Pena
	Fernando F. Pérez
Government of New Zealand	T. E. Donne
Government of Peru	Alejandro Garland
Government of Spain	Don Claudio de Azpiazu
Government of Switzerland	Arthur de Claparède.
Grimsby District Naturalists' Society, England	Ole T. Olsen
Harvard Travellers' Club, Massachusetts	Prof. William M. Davis
	Ernest Howe
Haute École des Ingénieurs, Moscow, Russia	Alexander W. Pavlow
Hull Young Men's West African Missionary Society	Rev. James Flanagan
Hydrographic Office, Navy Department, Washington, D. C.	Lieut. Commander H. M. Hodges
Imperial Geographical Society of Vienna, Austria	Dr. Emil Tietze
International Bureau of the American Republics, Washington, D. C.	Williams C. Fox
John Ryland's Library, Manchester, England	Rev. A. W. H. Streuli
Kaiserlich Königliche Geographische Gesellschaft, Vienna, Austria	Prof. E. Oberhummer
	Prof. Emile Tietze
Kolonial Gesellschaft zu Berlin, Germany	Franz Jansen
L'École des Langues Orientales, Paris, France	Prof. Paul Boyer
Manchester Geographical Society	J. H. Bentley
	W. T. Gunson
	H. C. Martin
	Rev. F. A. Rees
	Rev. S. A. Steinthal
Maritime Association, New York, N. Y.	C. B. Parsons
Mazamas, Oregon	R. L. Glisan
Meteorological Service, Canada	R. F. Stupart
Ministry of Public Instruction, Paris, France	Henri Cordier
Minnesota Geographical Society	Prof. L. W. Chaney
National Geographic Society, Washington, D. C.	Dr. L. A. Bauer
	Admiral C. M. Chester
	Dr. D. T. Day
	Henry Gannett
	G. K. Gilbert
	Dr. D. C. Gilman
	Gen. A. W. Greely
	G. W. Littlehales.
	Dr. W J McGee
	Mr. O. H. Tittmann.
	Dr. C. D. Walcott.

Institutions.	Delegates
National Observatory, Mexico	Felipe Valle
Natural Society of Thüringen, Nordhausen, Germany	Otto Quelle
Naturwissenschaftlicher Verein für Steiermark, Austria	Dr. Richard Marek
New York Academy of Science	Prof. J. F. Kemp
	Prof. J. J. Stevenson
Norske Turist Forening, Christiania, Norway	Capt. Edvard Amesen
Oswego State Normal School, New York	Amos W. Farnham
Philippine Weather Bureau	Oscar Halvorsen
Real Società Geografica Italiana	Count l'Aquemont
	Prof. Giuseppe Gambino
Royal Geographical Society, Austria	Dr. E. S. Fischer
Royal Geographical Society of Australasia	Col. J. M. Morgan.
Royal Geographical Society, Copenhagen, Denmark	Prof. Thorvald Thoroddsen
Royal Geographical Society of London, England	Capt. D. J. Kennelly
	Maj. A. St. H. Gibbons.
	J. Scott Keltie.
	H. R. Mill.
	H. Y. Oldham
Royal Scottish Geographical Society	James Muirhead.
Scientific Society, San Antonio, Texas	G. W. Brackenridge.
Sierra Club	D. S. Jordan
	Mark B. Kerr
Société Bretonne de Géographie, Lorient, France	Prof. E. de Martonne.
Société des Américanistes, Paris, France	Henri Cordier
Société de Géographie Commerciale de Paris, France	H. de Cuis de St. Aymour
	Charles Gauthiot.
	Comte M. de Perigny
Società Geografica Italiana, Rome, Italy	Prof. Attilio Brunialti
Société de Géographie de Lille, France	E. V. Boulanger
	Ernest Nicolle.
Société de Géographie de Paris, France	Col. Charles Chaillé Long.
	Guillaume Grandidier
Sociedade de Geographia do Rio de Janeiro, Brazil	José A. dos Santos.
	A. O. dos Santos Pires.
Société de Géographie de Toulouse, France	J. de Rey Pailhade.
Société de Géographie, Vienna, Austria	Dr. Theodor Cicalek.
	Henry Wallach.
Société Languedocienne de Géographie, Montpellier, France	Charles Flahault
Société Royale de Géographie d'Anvers, France	Henryk Arctowski.
Société de Topographie, Paris, France	Prof. Carlos de Mello.
Stanford University, California	President D. S. Jordan.
Technische Hochschule, Germany	Dr. Matthäus Haid.
Tokio Geographical Society, Japan	Eki Hioki.

Topographical Survey, Department of the Interior, Canada.	A. O. Wheeler.
United States Army	Col. A. H. Russell.
United States Board on Geographic Names	Andrew H. Allen.
	A. von Haake.
United States Department of Agriculture	John Hyde.
United States Department of State	Charles R. Dean.
United States Naval Observatory, Washington, D. C.	Lieut. Commander E. Everett Hayden.
United States Navy	Admiral C. M. Chester.
United States Treasury Department	Charles Lyman.
	Dr. Walter Wyman.
Universidad Central de Madrid	Prof. Mario de la Mata.
University of Commerce, Cologne, Germany	Dr. Kurt Hassert.
Université de Montpellier, France	Charles Flahault.
University of North Carolina	Prof. Collier Cobb.
Université de Paris, France	Prof. P. V. de la Blache.
University of Toronto, Canada	Prof. A. P. Coleman.
	Miss Lila Watt.
Verein für Erdkunde zu Darmstadt, Germany	Dr. Georg Greim.
Verein für Erdkunde, Dresden, Germany	Prof. B. Pattenhausen.
Verein für Erdkunde in Halle, Germany	Dr. Adolf Schenck.
Verein für Erförderung des Adriatischen Meeres, Vienna, Austria.	Dr. Albrecht Penck.
Verein der Geographen an der Universität, Vienna, Austria.	Do.
Württembergischer Verein für Handels-Geographie, Stuttgart, Germany.	Prof. August Schmidt.
	Theodor G. Wanner.
Yacht Club de France and Société des Regates Cannoises, Cannes, France.	René Lacour.

DIARY OF THE CONGRESS

WASHINGTON

Wednesday, September 7

9 p. m.—Informal reception at Hubbard Memorial Hall.

Thursday, September 8

10 a. m.—Formal opening of congress at the George Washington (Columbian) University Hall.

2 p. m.—Visits to scientific bureaus.

10 to 12 p. m.—Reception at the U. S. Naval Observatory by the Superintendent of the Observatory, Rear-Admiral C. M. Chester, U. S. Navy. An international telegraphic time signal and message were sent out.

Friday, September 9

10 a. m.—General session, devoted especially to governmental surveys.

2 p. m.—Sectional meetings.

5 p. m.—Reception by Mrs. Gardiner Greene Hubbard at Twin Oaks.

8 p. m.—Lecture by Mr. Charles M. Pepper, "The Bolivian Andes."

Saturday, September 10

10 a. m.—Sectional meetings.

2 p. m.—Sectional meetings.

8 p. m.—Reception by President and Mrs. Peary at the New Willard Hotel.

Sunday, September 11

10 a. m.—Excursion down the Potomac River to Mount Vernon.

7 p. m.—Congress left Washington for Philadelphia.

PHILADELPHIA

Monday, September 12

The day was devoted to sight-seeing, including Independence Hall, the Commercial Museum, and Fairmount Park.

6 p. m.—Dinner at the Country Club.

9.30 p. m.—Congress left Philadelphia for New York.

NEW YORK

Tuesday, September 13

10 a. m.—General session, held in the hall of the American Geographical Society.
2 p. m.—Sectional meetings.
8 p. m.—Lecture by Dr. and Mrs. Bullock Workman.
9.15 p. m.—Reception by the American Geographical Society in its building.

Wednesday, September 14

10 a. m.—General session.
11 a. m.—Sectional meetings.
2 p. m.—Sectional meetings.
8 p. m.—Dinner at Hotel Endicott.

Thursday, September 15

The day was spent in an excursion up the Hudson River to Mount Beacon and to West Point.

In the evening congress left West Point for Niagara Falls.

NIAGARA FALLS

Friday, September 16

The morning was devoted to sight-seeing.

12 noon.—Lecture by Mr. G. K. Gilbert on "Niagara Falls."

The afternoon was spent in riding from the head of the rapids to Lewiston, at the foot of the escarpment.

9 p. m.—Congress left Niagara Falls for Chicago.

CHICAGO

Saturday, September 17

10 a. m.—General session.

The afternoon was devoted to driving about the city, visiting points of interest.

Sunday, September 18

7 a. m.—Congress left Chicago for St. Louis, which was reached in the evening.

ST. LOUIS

Monday, September 19

The day was devoted to sight-seeing at the Louisiana Purchase Exposition.

Tuesday, September 20

10 a. m.—Participation in session of World's Congress of Arts and Sciences.

11.15 a. m.—Meeting with the department of geography of the earth of the world's congress.

2 p. m.—Meeting with the department of anthropology of the world's congress.

Wednesday, September 21

10 a. m.—Section of historical geography.

4 p. m.—Section of anthropogeography.

9 p. m.—Participation in the general reception by the German Imperial commissioner-general, at the Deutscheshaus.

Thursday, September 22

3 p. m.—Inspection of exhibits of geographic character, or participation in sectional meeting of the World's Congress of Geography.

8.30 p. m.—General session, lecture by Commander R. E. Peary, U. S. Navy.

10 p. m.—Final adjournment of the congress.

MINUTES OF THE GENERAL MEETINGS

FIRST MEETING

The Eighth International Geographic Congress assembled in the hall of the George Washington (Columbian) University, Washington, D. C., United States of America, at 10 a. m. of Thursday, September 8, 1904.

The meeting was called to order and the congress declared open by Commander R. E. Peary, U. S. Navy, president of the congress.

Dr. Charles D. Walcott, Director of the U. S. Geological Survey, in the name of the President of the United States, welcomed the foreign delegates to the Congress. The text of Dr. Walcott's address will be found on page 69.

Commander R. E. Peary announced the dispatch of a telegram to the President of the United States, thanking him for his acceptance of the office of honorary president of the congress.

Mr. G. K. Gilbert, vice-president of the National Geographic Society of Washington, D. C., welcomed the congress in the name of that society. The text of Mr. Gilbert's address will be found on page 71.

The president introduced Mr. Henri Cordier, representing the French Government, the Minister of Public Instruction, the Geographical Society of Paris, and the American Society of Paris. Professor Cordier, in the name of the French Government, and of the above societies, congratulated the congress upon its assemblage. The text of Professor Cordier's remarks will be found on page 73.

The president introduced Professor Dr. Albrecht Penck, representing the Geographical Society of the University of Vienna and the Association for the Advancement of Science, Vienna. In the name of these societies Professor Dr. Penck congratulated the congress upon its assemblage.

The president introduced Mr. H. Yule Oldham, representing the Royal Geographical Society of Great Britain and the Geographical Association of Oxford, England. In the name of these societies Mr. Oldham congratulated the congress upon its assemblage; also in the name of the remaining geographical societies represented at the congress.

Commander Robert E. Peary, U. S. Navy, president of the congress, delivered an address of welcome to the foreign delegates and members.

Commander Peary reviewed the progress of geography since the close of the Seventh Geographic Congress, held at Berlin in 1899, gave a résumé of the work yet to be accomplished before our geographic knowledge of the globe will be complete, and pointed out that the chief value of such meetings as the present lies in the stimulus given to geographic investigation. Commander Peary's remarks will be found in full on page 76.

The president introduced Professor Dr. Eugen Oberhummer, representing the Imperial Royal Geographical Society of Vienna and the Geographical Association of Munich.

Professor Dr. Oberhummer gave a résumé of the report of the executive committee of the Seventh Geographic Congress, held at Berlin in 1899, presented a copy of this report in full to the president of the present congress, and in the name of the several societies represented by him congratulated the congress upon its assemblage. Professor Dr. Oberhummer's remarks will be found in full on page 74.

The complete report of the executive committee of the Seventh International Geographic Congress will be found on page 83.

The president introduced his excellency the Minister from Switzerland to the United States.

His excellency introduced to the congress Mr. Arthur de Claparède, representing the Geographical Society of Geneva.

Mr. Arthur de Claparède, in the name of his society, congratulated the congress upon its assemblage, and in the name of the Swiss Government and of the Geographical Society of Geneva invited the congress to select Geneva as its place of meeting in 1908. The text of Mr. de Claparède's remarks will be found on page 75.

The president of the congress introduced Dr. Béla Erödi, representing the Hungarian Government and the Hungarian Geographical Society. Doctor Erödi, in the name of the Hungarian Government, invited the congress to name Budapest as its place of meeting in 1908.

The president of the congress announced the programme for the afternoon of September 8.

Admiral C. M. Chester, U. S. Navy, announced that the Secretary of the Navy would receive the congress at the United States Naval Observatory on the evening of September 8 from 10 to 12 p. m.

At 12.15 p. m. the congress adjourned.

SECOND MEETING

The congress assembled in the hall of the George Washington (Columbian) University at 10 a. m., September 9, 1904.

The congress was called to order by the president at 10.15 a. m.

The president stated that the meeting would be devoted to the consideration of the subject of Government surveys.

At the request of the president of the congress the chair was taken by Mr. G. K. Gilbert, vice-president of the National Geographic Society.

The presiding officer stated that in the general meetings of the congress the time allotted to the presentation of each paper would be limited to twenty minutes, with ten minutes additional for discussion; in sectional meetings the time allotted to each paper would be limited to fifteen minutes, with five minutes additional for discussion.

The presiding officer called upon Dr. Adolf Marcuse for his paper entitled "Recent development in the determination of geographical positions," which was read.

The paper was discussed by Mr. Carlos de Mello.

The text of the paper will be found on page 551.

The presiding officer called upon Mr. Arthur O. Wheeler for his paper entitled "Photographic methods employed by the Canadian survey."

The paper called forth discussions by Mr. G. K. Gilbert, Prof. H. F. Reid, and Mr. F. E. Matthes.

The text of the paper will be found on page 541.

The presiding officer called upon Mr. J. F. Hayford for his paper entitled "Recent practice in the U. S. Coast and Geodetic Survey in triangulation, base measurements, and leveling."

The text of the paper will be found on page 531.

The presiding officer called upon Mr. F. E. Matthes for his paper entitled "Topographic methods used for the new detail maps of the Grand Canyon of the Colorado River."

An abstract of this paper will be found on page 801.

The presiding officer called upon Col. A. Laussedat, of Paris, for his paper entitled "Sur les origines de l'art de lever les plans à l'aide de la photographie."

In the absence of Colonel Laussedat, this paper was read by title only.

The text of the paper will be found on page 580.

The presiding officer called upon Prof. Albrecht Penck, of Vienna, Austria, for his paper entitled "The map of the world on a scale of 1:1,000,000."

Professor Penck closed his paper by offering the following resolutions:

1. The Eighth International Geographic Congress at Washington presents its thanks to the Service géographique de l'armée at Paris, to the Kartographische Abtheilung der Königlich-Preussischen Landesaufnahme in Berlin, and to the intelligence division of the war office in London, for having commenced the publication of large maps on the scale of 1:1,000,000, which correspond in a general way to the maps of the world proposed by the congress at Berne, and it invites these offices to prepare an account

of their maps, accompanied, if possible, by parts of them for publication in the report of the Washington meeting.

2. The congress proposes to the Government of the United States the execution of a general map of America on the scale of 1:1,000,000, similar to the maps on the same scale of Asia, China, and Africa, now in course of preparation by the Service géographique de l'armée at Paris, by the Königlich Preussische Landesaufnahme in Berlin, and by the intelligence division of the war office at London, each sheet of the map being projected on its own plane, and being limited by parallels 4° apart and meridians 6° apart, the initial meridian for the division being that of Greenwich, the initial parallel the equator, the standard of measures being the meter.

The presiding officer stated that these motions would be referred to the presidency of the congress for action.

The text of Professor Penck's paper will be found on page 553.

The presiding officer called upon Col. Carroll D. Wright for his paper entitled "The demographic investigation of countries without censuses."

Colonel Wright closed his paper by offering the following resolution:

That a committee of five be appointed by the president, to confer with a committee of the International Statistical Institute, on methods of obtaining the population in countries taking no census.

The motion was referred to the presidency of the congress for action.

The text of Colonel Wright's paper will be found on page 678.

The presiding officer announced that all members who contemplated taking part in the proposed excursion to the Grand Cañon and the City of Mexico must obtain their tickets prior to 8 p. m. of September 9.

The secretary of the congress announced the receipt of numerous replies to the time signal dispatched from the U. S. Naval Observatory at midnight of September 8. The reply received from the island of Guam invited the Congress to name that island as its place of meeting in 1908.

At 12.40 p. m. the congress adjourned.

THIRD MEETING

The congress assembled in the hall of the American Geographical Society, New York City, at 10 a. m., September 13, 1904.

The meeting was called to order by Commander R. E. Peary, U. S. Navy, president of the American Geographical Society, president of the congress.

In his opening remarks the president of the congress commented upon the closer relation which the study of geography should bear to the commercial interests of the country.

The president expressed regret at the death of the late Judge Charles P. Daly, to whom the American Geographical Society owes its existence.

Upon conclusion of these remarks the president called upon Dr. Martha K. Genthe, who presented an appreciative memorial of the late Friedrich Ratzel. The text of this memorial will be found on page 1053.

The president of the congress called upon Sir John Murray, of Edinburgh, Scotland, for his paper entitled "Deep sea deposits." An abstract of this paper will be found on page 407.

Upon conclusion of the reading of this paper the president of the congress requested Sir John Murray to assume the duties of chairman of the meeting.

Upon assuming the chair, Sir John Murray called upon Graf Joachim von Pfeil und Klein Ellguth, of Lauban, Germany, for his paper entitled "Rise and development of the German colonial possessions."

In the temporary absence of Graf von Pfeil the chair called upon Dr. E. O. Hovey, of the American Geographical Society, for his paper entitled "The volcanoes of Martinique, Guadeloupe, and Saba." The text of this paper will be found on page 447.

The chair called upon Graf von Pfeil for his paper as above. The text of this paper will be found on page 823.

The chair announced that paper entitled "Campagnes et travaux océanographiques de S. A. S. le Prince de Monaco," by Prof. Thoulet, of Nancy, France, would be read at the afternoon session of "Section D. Oceanography."

The chair made the following announcements:

1. A meeting of the presidency of the congress at 12.30 p. m. of September 13.

2. A meeting of the presidency of the congress at 10 p. m. of September 13, to discuss the report of the executive committee of the Seventh International Geographic Congress.

3. A meeting of the presidency of the congress at 9 a. m. of September 14, to discuss the place of meeting of the Ninth International Geographic Congress.

At 12.15 p. m. the congress adjourned.

FOURTH MEETING

The congress assembled in the hall of the American Geographical Society, New York City, at 10.10 a. m. of September 14, 1904.

The meeting was called to order by Commander R. E. Peary, U. S. Navy, president of the congress.

The chair called upon Mr. Henry Gannett, secretary of the congress, for the action of the committee appointed to consider the report of

the executive committee of the Seventh International Geographic Congress.

The secretary read the report of this committee, giving the action taken by the presidency with regard to each paragraph (see page 60).

Professor Penck offered the following resolution:

In view of the interest attaching to the lantern slides exhibited by Mr. Sieberg and the photographs exhibited by Mr. Willis, it is desirable that in these and similar cases photographs of geographical significance might be published and accompanied by short explanatory notes, so that they may form collections of representative physical features of different parts of the world.

The resolution was adopted.

Professor Libbey discussed the formation of a union for exchange of courtesies among the principal geographic societies.

Dr. Hugh Robert Mill, speaking for the Royal Geographic Society, approved of Professor Libbey's suggestion.

Mr. Henry Walbach, of the Royal Geographic Society, favored the suggestion.

Professor Libbey offered the following resolution:

That the president of the congress appoint a committee consisting of eight members of the present congress who shall formulate a plan for a union among the principal geographic societies for the exchange of courtesies.

The resolution was adopted.

The chairman appointed as members of this committee the following: William Libbey, Princeton, chairman; Henri Cordier, Paris; H. R. Mill, London; Albrecht Penck, Vienna; Arthur de Claparède, Geneva; Erich von Drygalski, Germany; Felipe de Valle, Mexico; [illegible], Washington.

The chair called upon Professor Penck for the report of the International Cartographic Association.

Dr. Thoulet, for Professor Penck, read the paper of Colonel Schokalsky upon this subject.

Professor Penck offered the following resolution:

The congress refers the propositions of Colonel Schokalsky and the paper of Mr. [illegible] to the committee appointed by the Congress of Berlin concerning a cartographic association. This committee is requested to report on the necessity of a cartographic association to the next congress. In the meantime it might interest geographical societies in the plan and in the necessity of dealing with maps in geographical journals in a more detailed way than usual, and take such steps that the general use of maps may be popularized and extended in school instruction and that [illegible] be otherwise regulated.

[illegible] Mr. [illegible] the congress hereby [illegible] Washington, D. C., [illegible] Schokalsky, of St. Petersburg, [illegible] Mr. J. [illegible]

Sir John Murray seconded Professor Penck's resolution.

The resolution was adopted.

The chair called upon Mr. P. Vidal de la Blache for information as to geographic bibliography.

Mr. Vidal de la Blache tendered to the congress a brochure upon the question.

Doctor Thoulet offered a resolution recommending the adoption of the terminology employed by Doctor Supan.

Professor Penck and Professor Oberhummer spoke in support of the resolution.

The resolution was adopted.

The meeting adjourned at 11.05 a. m.

FIFTH MEETING

The congress assembled in Kent Theater, University of Chicago, Chicago, Ill., at 10 a. m., September 17, 1904.

Dr. Rollin D. Salisbury introduced President W. R. Harper, of the University of Chicago.

President Harper delivered an address of welcome to the congress.

Commander R. E. Peary, U. S. Navy, president of the congress, responded, declaring the meeting open.

The president of the congress requested Dr. Rollin D. Salisbury, of the University of Chicago, to assume the duties of chairman of the meeting.

Having assumed the chair, Doctor Salisbury recognized Mr. Henry Gannett, secretary of the congress.

Mr. Henry Gannett offered the following resolution:

Be it resolved, That a committee be appointed by the president to represent the different countries interested in geographic education in their respective countries, and to report thereon; such reports to be published biennially in one of the leading geographic magazines of each country represented.

Prof. William M. Davis seconded the resolution.

By a vote of the congress the resolution was adopted.

The chair called upon Prof. Albrecht Penck for his paper entitled "The last uplift of the Alps."

The chair called upon M. Guillaume Grandidier, of Paris, France, for his paper entitled "Madagascar before the French occupation and to-day."

The chair called upon Dr. Hugh Robert Mill, of London, England, for his paper entitled "Geographic elements."

The chair requested Prof. G. K. Gilbert to assume the duties of chairman temporarily.

Upon assuming the chair, Professor Gilbert called upon Dr. Rollin D. Salisbury for his paper entitled "Physical geography of Chicago."

Prof. G. K. Gilbert relinquished the chair to Dr. Rollin D. Salisbury.

The chair called upon Dr. J. Paul Goode, University of Chicago, for his paper entitled "Economic geography of Chicago."

Professor Penck asked for information as to opportunity to inspect some of the commercial features of Chicago.

The chair explained that, owing to unforeseen circumstances, such opportunity would not be afforded.

At 12.11 p. m. the congress adjourned.

SIXTH MEETING

The congress assembled in Festival Hall, World's Fair, St. Louis, at 8 p. m., September 22, 1904.

President Peary delivered an address on Arctic exploration.

The following resolution was introduced and agreed to:

Resolved, That the president appoint a committee of five, with power to add to their number, to conduct the business that may arise from this congress, and to report to the Ninth International Geographic Congress.

The congress then adjourned sine die.

MINUTES OF MEETINGS OF THE PRESIDENCY

FIRST MEETING

The presidency of the congress assembled in the parlor of the Ebbitt House, Washington, D. C., at 2 p. m. of September 8, the president in the chair.

After the transaction of executive business, it was moved by Prof. William M. Davis:

1. That in the meetings of the several sections the first paper shall in each case be read by an American; this to be followed by foreign papers until the number from this source has been exhausted; these followed in turn by American papers.

2. That the order of succession of the various papers shall be determined by the secretary of each section, subject only to the above restriction.

3. That the secretary of the section shall, prior to the meeting of the section, furnish the secretary of the congress with a list, showing the proposed order of presentation of the various papers, and that the secretary of the congress shall cause such lists to be printed.

Adopted.

Moved by Professor Libbey:

That the American Geographical Society of New York be permitted to extend the privilege of attendance upon the public lectures to nonmembers.

Adopted.

Moved by Dr. J. H. McCormick (for Miss Zonia Baber):

That the Geographic S... ...icago be permitted to extend the privilege of attendance upon the pub... ...nonmembers.

Adopt...

Move... ...ss...

That ... ...on ... ...ber 13 be made general in place of spec...

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...l. Carroll D. Wright, entitled ... be read at a general instead of

...ight be placed upon the programme

Moved by Mr. Henry Gannett:

That the president appoint a committee of three to consider the question of reports, etc., submitted by committees of the Seventh Geographical Congress and resolutions offered for consideration of the present congress.

Adopted.

The president named Messrs. Davis (chairman), Gannett, and Heilprin members of this committee.

Moved by Professor Libbey:

That the presentation of maps be made a part of the business of the general session of September 9.

Adopted.

Moved by Dr. J. H. McCormick:

That a request on the part of the author to demonstrate the applicability of the kammatograph to surveying be referred to "Section H, Geodesy."

Adopted.

Moved by Dr. J. H. McCormick:

That all papers presented to the congress and discussions of the same shall be submitted to the secretary of the congress in writing.

Adopted.

At 3.15 p. m. the meeting of the presidency adjourned.

SECOND MEETING

The presidency of the congress assembled in the hall of the American Geographical Society, New York City, at 10 p. m. of September 13, 1904; Commander R. E. Peary, U. S. Navy, president of the congress, in the chair.

The chair stated that the purpose of the meeting was the discussion of the report of the committee appointed to consider the report of the executive committee of the Seventh International Geographic Congress.

Prof. William M. Davis, chairman of the committee appointed to consider the report, submitted a series of resolutions for action, as follows:

1. *The Bibliotheca Geographica* being a compendious international bibliography, no action is recommended on this subject.

2. *Map of the world, 1:1,000,000.*—The report of the executive committee is supplemented by the motions made by Professor Penck to the present congress; favorable action is recommended when these motions are presented.

3. *Antarctic explorations.*—The votes and hopes of the seventh congress have been wonderfully realized. A new motion bearing on this subject will be presented.

4. *Earthquake investigations.*—The formation of the International Seismological Association has accomplished the wishes of the seventh congress in this respect. It is moved that the Eighth International Geographic Congress sends its congratula-

tions to the International Seismological Association, whose further work is waited for with great interest.

5. *Investigation of lakes.*—The chairman of the committee on this subject reports that while several limnological studies have been carried forward, it has not been possible to secure results through action of the committee. It is therefore recommended that no further action be taken on this subject and that the committee be discharged.

6. *Nomenclature of the ocean bottom.*—Effective action has been taken on this subject by a committee appointed for the purpose, and the results have been published. The committee was also instructed to promote the preparation and publication of a map of the deep oceans. Professor Thoulet reports on behalf of the Prince of Monaco concerning the progress of this map. It is recommended that the thanks of the congress be voted to the committee for its effective labors, and to the Prince of Monaco for the publication of the map sheets now issued, and that the committee be continued.

7. *Nomenclature of plant formations.*—No results having followed the vote on this subject, no further action is recommended.

8. *International Cartographic Association.*—No results are reported by the executive committee on this subject. A communication has been received from M. Schrader, which will be presented later.

9. *Rules for geographic names.*—It is recommended that these conservative rules be reaffirmed and that geographical societies be urged to give them wide publicity.

10. *Indication of sources of information on maps, etc.*—No action is recommended on this subject.

11. *Indication of the fractional scale of maps.*—It is recommended that the vote on this subject be reaffirmed and that geographic societies be urged to give it wide publicity.

12. *The decimal system.*—The same recommendation is made as for No. 11.

13. *Time and circle division.*—No action is recommended.

14. *Ocean investigation.*—This subject is now under consideration by the Central Committee for International Ocean Investigation, at Copenhagen. No specific action is recommended.

15. *Collection of records of drift ice.*—This work is progressing satisfactorily in charge of the Danish Meteorological Institute, with the cooperation of various national offices. It is recommended that the thanks of the congress be sent to the Danish Meteorological Institute and the cooperating offices for their systematic collection of records of drift ice.

16. *Statistics of population in countries without census.*—This subject is considered in a motion made by Col. C. D. Wright, which will be introduced later.

17. *Statistical base map.*—No action is recommended.

18. *Maps of prehistoric settlements and burial grounds.*—No action is recommended.

19. *Search for remains of Leichhardt's expedition in Australia.*—An expedition is now in progress with this object. No action is recommended.

20. *Transcription.*—Nothing has been accomplished under the vote on this subject. No action is recommended.

The chair announced that before proceeding with the discussion of the report submitted by Professor Davis the congress would hear all resolutions pertaining to other matters.

Sir John Murray offered a resolution with regard to polar research.

At the suggestion of Professor Davis the consideration of this motion was deferred until the paragraph in the report of the committee bearing upon this subject should have been discussed.

Lieut. Commander Everett Hayden offered the following resolution:

Resolved, That in view of the fact that a large majority of the nations of the world have already adopted systems of standard time based upon the meridian of Greenwich as prime meridian, this congress is in favor of the universal adoption of the meridian of Greenwich as the basis of all systems of standard time.

The resolution was adopted.

Professor Libbey spoke in reference to a resolution adopted by "Section D, Oceanography," concerning the oceanographic investigations conducted by the Prince of Monaco.

At the request of Professor Davis the consideration of this question was deferred until the paragraph in the report of the committee bearing upon the matter shold have been discussed.

Professor Heilprin offered a resolution concerning publicity of resolutions adopted by the congress.

Professor Penck asked permission to read the paper by Colonel de Schokalsky concerning the organization of an international cartographic association.

Professor Libbey moved that the matter of an international cartographic association be discussed at the next general meeting of the Congress.

The motion was adopted.

Dr. Oberhummer offered a resolution with regard to the use of topographic maps in the United States.

The presidency took up the consideration of the preliminary report of the committee appointed to consider the report of the executive committee of the Seventh International Geographic Congress.

It was decided that each paragraph should be considered separately.

Paragraph 1: International bibliography.—The paragraph was accepted as read.

Paragraph 2: Map of the world on a scale of 1:1,000,000. The paragraph was accepted as read.

On a motion of Professor Davis, Professor Penck's resolutions 1 and 2 (see pages 53–54) were adopted.

Paragraph 3: Antarctic exploration.—The paragraph was accepted as read.

On motion, the resolution of Sir John Murray as to polar research was adopted.

The resolution is as follows:

The Eighth International Geographic Congress, realizing that the only untouched fields for geographical discovery are the regions surrounding the poles of the earth, desires to place on record its sense of the importance of forthwith completing the systematic exploration of the polar areas. It is very desirable that the experience gained by men of science and officers in the recent Antarctic expeditions should be turned to account by following up without delay the successes they have obtained.

The congress recognizes that the Arctic regions possess a more immediate interest for the people of North America, and expresses the confident hope that the expedition now being prepared will be so supported as to secure early and complete success.

Paragraph 4: Earthquake investigations.—The paragraph was accepted as read. The tender of congratulations to the International Seismological Association was agreed to.

Paragraph 5: Investigation of lakes.—The paragraph was accepted as read.

Professor Davis moved that the committee on lake investigation be discharged.

The motion was adopted.

Paragraph 6: Nomenclature of ocean bottom.—Professor Libbey was of the opinion that there was no necessity of continuing the committee.

Dr. Thoulet agreed with Professor Libbey.

The part of the paragraph calling for the continuance of the committee was accordingly rejected.

The thanks of the Congress to the Prince of Monaco were expressed as follows:

The Eighth International Geographic Congress expresses its thanks to His Serene Highness the Prince of Monaco for having executed the map of the ocean, the construction of which was desired by the congress of Berlin, and expresses especially its agreement with the chosen scale and projection, with the adoption of the meridian of Greenwich as initial, with the adoption of the meter for the indications of the depths, and with the principle of the system of international submarine terminology employed.

Paragraph 7: Nomenclature of plant formations.—The paragraph was accepted as read.

Paragraph 8: International Cartographic Association.—The paragraph was accepted as read.

Paragraph 9: Rules for geographic names.—The paragraph was accepted as read.

Paragraph 10: Indications of sources of information on maps, etc.—The paragraph was accepted as read.

Paragraph 11: Indication of the fractional scale on maps.—The paragraph was accepted as read.

Paragraph 12: The decimal system.—The paragraph was accepted as read.

Paragraph 13: Time and circle division.—The paragraph was accepted as read.

Paragraph 14: Ocean investigation.—The paragraph was accepted as read.

Paragraph 15: Collection of records of drift ice.—The paragraph was accepted as read. The recommendation as to extending the thanks of the congress to the Danish Meteorological Institute was adopted.

Paragraph 16: Statistics of population in countries without census.—On a motion by Professor Davis, the resolution of Col. Carroll D. Wright on the subject (see page 54) was adopted.

Paragraph 17: Statistical base maps.—The paragraph was accepted as read.

Paragraph 18: Maps of prehistorical settlements and burial grounds.—The paragraph was accepted as read.

Paragraph 19: Search for remains of Leichhardt's expedition in Australia.—The paragraph was accepted as read.

Paragraph 20: Transcription.—The paragraph was accepted as read.

Professor Penck states that the transcription of geographic names is a most important matter, and that he would like to recommend the question to the next congress.

Professor Cordier agrees with Professor Penck.

Professor Davis inquires as to the practice of preceding congresses as to action upon the report; whether it is to be referred to a general meeting of the congress, or whether the action of the present meeting is to be accepted as final.

It was decided that the action of the present meeting is the voice of the congress, and that the action taken need only be reported at the general meeting.

Professor Davis spoke in reference to a suggestion by Professor Penck (see page 56) as to the publication of lantern slides and photographs.

Dr. Theobald Fischer offered a resolution regarding geographical instruction.

The resolution was not adopted.

The meeting of the presidency adjourned at 11.05 p. m.

The resolutions, as adopted, will be found on pages 107–110.

THIRD MEETING

The presidency of the congress and the foreign delegates assembled at 9.30 a. m., September 14, in the hall of the American Geographical Society, New York City; Commander R. E. Peary, U. S. Navy, president of the congress, in the chair.

The chair stated that the business of the present meeting was to determine the place of holding the Ninth International Geographic Congress. Two invitations from foreign governments had thus far been received the first from the Government of Switzerland to hold the congress in the city of Geneva in 1908; the second from the Hungarian Government to hold the congress in the city of Budapest.

The chair called upon Prof. Arthur de Claparède, delegate of the Swiss Government and of the Geographical Society of Geneva, for a specific statement of the former invitation.

Professor de Claparède presented a letter from the Swiss Government containing the invitation.

The chair called upon Dr. Erödi for a statement of the invitation on the part of Budapest.

Dr. Erödi spoke for Budapest.

Professor Davis suggested that the vote for the present should be informal and should not be placed on record.

Professor Heilprin desired to hear statements from members of the congress as to the relative advantages offered by the two cities in question.

Capt. David J. Kennelly, of the Royal Geographic Society of Great Britain, expressed himself in favor of Geneva.

Sir John Murray called the attention of the congress to the fact that one international congress had already been held in Switzerland; also to the fact that Budapest had extended an invitation to the present congress.

Professor Heilprin called attention to the central location of Budapest, standing as it does on the limits of orientalism.

Mr. Henry W. Trinder, delegate from the Royal Geographic Society of Great Britain, expressed himself in favor of Geneva, calling attention to the disturbed political conditions in Budapest, and the probability of future greater disturbances.

Mr. George Henry Ball, of the Liverpool Geographical Society, expressed himself in favor of Budapest on the ground that there was more to be gained of a geographic nature in the locality, standing as it does in the midst of a different sphere of civilization.

M. Henri Cordier expressed himself in favor of Geneva.

Mr. Hugh Robert Mill stated that the deciding factor should be "Where will the science of geography be most advanced?" "Where will the largest number of geographers assemble?"

Dr. David T. Day stated that he would willingly favor Budapest for the Tenth International Geographic Congress, but that the fiftieth anniversary of the Geneva society could not be more appropriately celebrated than by holding the Ninth International Geographic Congress in that city. He hesitated to make the holding of a second congress in the same country a precedent for refusal, inasmuch as America looked forward to many of these congresses.

The chair stated that the vote about to be taken would be informal and the number of votes passed for either city would not be recorded.

A show of hands proved that the congress was in favor of Geneva as the place of meeting for the Ninth International Geographic Congress.

Dr. Day thereupon moved that the vote in favor of Geneva be made unanimous.

Adopted.

Professor de Claparède, in the name of the Swiss Government and and of the Geographical Society of Geneva, expressed his appreciation of the honor done his country.

Professor Heilprin moved that the thanks of the congress be extended to the Swiss Government and to the Geographical Society of Geneva; also to the Hungarian Government and the Geographical Society of Hungary for their valued invitations.

The motion was adopted.

The chair instructed the secretary to prepare appropriate resolutions to this effect.

The meeting adjourned at 10 o'clock.

ADDRESSES, REPORTS, AND RESOLUTIONS

ADDRESS OF WELCOME ON THE PART OF THE PRESIDENT OF THE UNITED STATES

By Dr. C. D. WALCOTT
Director United States Geological Survey

MR. PRESIDENT, MEMBERS OF THE CONGRESS, LADIES AND GENTLEMEN: It was the hope of your honorary president, the President of the United States, to attend in person to open this first session of your congress and welcome you to Washington in the name of the people of our country; but as this was impracticable he has asked me to represent him in fulfilling this pleasant duty. This is the first time that your body has met on this side of the Atlantic, and it is a very appropriate and timely visit. We have with our Canadian and Mexican neighbors a large country containing a great variety of geographic features, and in the work of making it a fit place of abode for the American people geographic factors have had much influence. Hence the study of our own geography has had a practical bearing as well as a theoretical interest to us, and it has received much attention. Recent events, moreover, have intensified the interest of the American people in geography and expanded the field of their study to the limits of the earth. The United States has recently been placed in a position involving widespread duties and responsibilities. While other countries—such as Great Britain, Germany, France, and the Netherlands—have for generations borne the burden of policing the remoter parts of the earth, this country has until recently taken little part in those labors.

The expansion of the country has increased the geographic knowledge of the mass of the people, for the country's welfare holds the attention of every citizen. Our interests in the Philippines have quickened our thought concerning the problems of all the East. While all aspects of geography—mathematical, physical, ethnologic, biologic, and political—have had a great revival among us, we are, perhaps, especially and most directly concerned with the commercial aspects of the science.

You will find the General Government doing here in Washington and throughout the country a large amount of work of geographic character, through the Coast and Geodetic Survey, the Geological

we are the merest tyros. And now that you, the geographers of the Old World, have come to our shores, we are eager to listen to all that you have to tell us.

The National Geographic Society, having its home at the seat of government and including in its membership the official geographers of the nation, is peculiarly appreciative of the opportunities afforded by this occasion, is peculiarly grateful that you have consented to favor us by your presence. On behalf of that society I offer you a hearty welcome to our land and to our city; on behalf of that society I extend to you the warm hand of hospitality.

ADDRESS OF MR. HENRI CORDIER

MR. PRESIDENT, LADIES, AND GENTLEMEN: I can hardly feel a stranger in this beautiful city, designed by Pierre L'Enfant, where the statues of so many of my countrymen stand and where I receive such a kind welcome.

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ADDRESS OF PROFESSOR EUGEN OBERHUMMER

MR. PRESIDENT, LADIES AND GENTLEMEN: Before entering on my subject allow me, please, to offer you, in this somewhat imperfect manner of expressing myself, the heartiest greetings on behalf of the country which I have the honor to represent at this congress, and in particular on behalf of the Imperial Austrian Ministry of Education; likewise on behalf of the geographic societies of Vienna and of Munich, where I had been at work previous to my appointment to the University of Vienna.

I will now add in a brief manner to these words of welcome a commission intrusted to me at the last moment by the committee of the last International Geographic Congress of Berlin. As unfortunately no member of the committee was able to attend this meeting, my friends, Professor von Drygalski and Professor von den Steinen, being both prevented at the very last moment, the president, Baron von Richthofen, has requested me, as a member of the last congress and of the Berlin Geographic Society, to present to you the report of the executive committee concerning the resolutions passed by the late congress held in Berlin in 1891. Those present at that congress will remember the great number of resolutions placed before it—some of great importance—which it was the duty of its committee to carry out before its reassembling here. To this report has been added a memoir by Professor Gerland, of Strassburg, referring to the International Seismological Association.

I think it is superfluous for the purpose of this meeting to read the report, as it will be printed and added to the proceedings. It gives me great pleasure to place this report in the hands of the president of this congress. I only regret that no person more competent than myself was charged with this commission.

I earnestly hope that you will make due allowance for the inefficiency of my English, with which language, as you will perceive, I am somewhat at war. Please accept my very best wishes for the success of this congress.

DISCOURS DE M. DE CLAPARÈDE, DR. JUR., DÉLÉGUÉ DU GOUVERNEMENT SUISSE

MONSIEUR LE PRÉSIDENT, MESDAMES, MESSIEURS: Vous voudrez bien m'excuser de parler dans une langue, peut-être étrangère à la majorité de cette assemblée—mais je ne puis malheureusement pas faire autrement, et dans un congrès international le français, d'ailleurs, est nécessairement licite.

Au surplus, je n'ai que deux mots à dire.

Le Conseil fédéral de la Confédération Suisse, en me déléguant officiellement pour le représenter à ce congrès, m'a chargé d'inviter, en son nom, le Neuvième Congrès International de Géographie à siéger à Genève, en 1908, à l'occasion du cinquantième anniversaire de la fondation de la Société de Géographie de Genève, qui date du 28 mars 1858.

Sans doute, Genève, ville de faibles dimensions, et la Suisse, petit pays, ne sauraient prétendre offrir au prochain congrès ce que Londres en 1895 et Berlin en 1899 ont offert aux derniers congrès, ni ce que les Etats-Unis présentent aujourd'hui au Huitième Congrès, qui va déambuler de Washington à Philadelphie, à New-York, à Chicago et à Saint-Louis. Mais, dans une sphère plus modeste et dans des proportions beaucoup plus humbles, la Société de Géographie de Genève réservera aux géographes des deux mondes, qui—si la proposition de la Suisse est acceptée—fêteront avec elle son cinquantième anniversaire, en 1908, l'accueil le plus cordial, le plus sympathique et le plus empressé; et l'Université de Genève, qui n'est que la continuation de la vieille Académie fondée par Calvin en 1559, et qui a contribué dans une si large mesure au développement scientifique et au mouvement intellectuel genevois, vous est un sûr garant des ressources de tout genre que les savants trouveront dans nos murs. Genève est d'ailleurs, par excellence, en Europe, la ville des congrès internationaux, ce qui s'explique par le cosmopolitisme intense qui l'anime.

J'aime à espérer que le congrès fera un favorable accueil à l'invitation du gouvernement Suisse et de la Société de Géographie de Genève. J'aurai l'honneur de donner connaissance au congrès, dans la séance où la question sera examinée, d'une lettre y relative du président de la Confédération Suisse. Genève serait heureuse et fière que vous voulussiez bien accepter sa modeste invitation. J'ose vous la recommander chaleureusement.

ADDRESS OF THE PRESIDENT OF THE CONGRESS

By Commander ROBERT E. PEARY, U. S. Navy

GENTLEMEN, DELEGATES, AND MEMBERS OF THE EIGHTH INTERNATIONAL GEOGRAPHIC CONGRESS: For the first time, America welcomes you and is honored by your presence. For the first time we have the pride and pleasure of extending a hearty greeting to our distinguished friends and coworkers in the great mother science, gathered from the civilized nations of the world.

For the eighth time since its inception the International Geographic Congress meets to note the progress of discovery, to listen to the results of the researches of its fellows, and to suggest and plan for the future. Seven times it has met in the great capitals of Europe; now it meets in the capital of your young sister, America.

Numbers of you meet here again comrades of previous congresses. Others have attended their last congress, and survive only in their works. Stanley and Nordenskjold, captains of the Tropics and the Arctic, have passed away in the quiet of their homes, their strenuous work ended years ago. Daly and Du Chaillu have died amid the peaceful surroundings of civilization. Andrée and Toll have met their fate in the stress of struggle with the icy North.

Since the last congress there have been numerous "world happenings," which, while not purely geographic, it may be well perhaps to note here.

When the last congress met a struggle had been finished in the distant East—a struggle far-reaching in its effects, which mark the beginning of a new policy, a new line of thought and action, the first step in the inevitable and inexorable destiny of this country.

At the present time another struggle is going on in the same region, fateful with the greatest possibilities to two of our friends and neighbors.

Since the last congress two republics have ceased to exist in Africa and a new one has been born in America.

In Asia a great new line of communication has been completed—the Trans-Siberian Railway.

Along the wide floor of the Pacific a world nerve vibrates to-day which did not exist when you last met—the new Pacific cable.

Wireless telegraphy is an accomplished fact to-day, not an experiment, and the atmosphere of the globe in a short time will throb incessantly with countless messages.

Finally, there is that vision of the centuries, that envious dream of monarchs and ministers since Gomara quested for the "Secret of the Strait" four hundred years ago—the Isthmian Canal, the union of the Atlantic and the Pacific—the grandest project, the greatest engineering, financial, and diplomatic problem of the age. A fearless master hand has at a stroke cut the Gordian tangle that has hitherto defied the ablest statesmen and financiers of the world, and the nations to-day accept without question the Panama Canal as a fact. A few years hence and the commerce of the world will pass freely from the eastern sea to the western sea, traversing almost air lines from port to port, at an enormous saving of time and distance and expense, and this great orient-and-occident-facing republic will rest content with coasts united from Eastport to the Straits of Fuca.

Much has been done in the geographical world since the last congress, both in the field and in the study, and the number of possible great discoveries is rapidly narrowing every year.

Only two great prizes now wait the present-day explorer—the north pole and the south pole.

It is interesting to note how, from congress to congress, the scene of geographical interest shifts from one region to another. Africa, Arctica, Antarctica have followed in succession. What will it be next, or will some of the old loves continue to claim our advances until full surrender?

The most prominent feature of geographical work since the last congress has been the activity in Antarctic exploration. The international programme formulated at the last two congresses has been carried out, and a large and valuable amount of work done and material secured. England, Germany, Sweden, Scotland, Belgium, and France have all sent ships to this region, and the result has been wonderfully to increase our knowledge of that most interesting portion of the globe. I shall not attempt any details or discussion. These we shall have first hand from those who have led the expeditions and been intimately identified with them.

In the Arctic field there has been continued activity. Abruzzi, the able and energetic young Italian duke, has in a splendid and effective dash recorded the nearest approach to the pole, and has by his experience eliminated Franz Josef Land from further consideration as a polar base. Such type of young man, possessing already the prestige of a distinguished name, devoting his time, his abilities, his personal means to the advancement of human knowledge, instead of wasting them upon idle amusement, commands our highest admiration.

Survey, the Weather Bureau, the Biological Survey, the General Land Office, the Census Office, and numerous other bureaus and offices. Many million dollars are annually expended in extending and disseminating geographic knowledge. We shall be glad to have you visit and examine these departments.

Those of you who have come from other lands will find the United States a country keen to learn the science of the earth, and full of interest in the scientific and practical phases of geographic work. The presentation and discussion of the numerous geographical questions announced in the well-filled programme will command the attention of our people. It now remains for me to thank you all for coming to our nation's capital and to extend to all members of the congress a most cordial and sincere welcome.

ADDRESS OF WELCOME ON BEHALF OF THE NATIONAL GEOGRAPHIC SOCIETY

By G. K. GILBERT
Vice-President National Geographic Society

Mr. President, Delegates of Foreign and American Societies, Governments, and Governmental Bureaus, Members and Associate Members of the Eighth International Geographic Congress: In greeting you on behalf of the National Geographic Society I trust I may be pardoned by our American guests if I speak more especially to those who have come to us from other countries.

Your visit to our land finds us in the midst of a period of exceptional growth of geographic interest. As you have just been told in the message brought by Dr. Walcott from the President of the United States, our geographic outlook as a nation has been revolutionized by the recent acquisition of a number of insular dependencies. While our people as individuals are divided in opinion as to the advantage of that acquisition, we are of one mind in accepting the responsibility involved and in recognizing the need of a colonial policy and a colonial system. With that acceptance and that recognition comes a new need for broad geographic knowledge, and the nation is eager, as never before, for information on a wide range of geographic subjects and an important array of geographic problems. Books of travel are in demand, our magazines teem with descriptions of countries and peoples, and our universities are active in preparation to meet the demand for elaborate courses of geographic study. In these matters we are treading paths that for generations have been familiar to the advanced nations of Europe. And so, that we may profit by your wide experience, we are inquiring how geography is taught in foreign universities, and are asking how the colonies of European nations are managed and with what success.

In the field of physical geography we have long been active and we have felt that we were measurably in touch with the geographic scholars of other lands; but in the geography of countries, in the geography of industries, and in the geographic problems of administration

The south pole, from a practical geographic point of view, is no less a prize (but I do not consider it a greater) than the north pole, but the north pole has a place in history, in literature, in sentiment, if you will, which the south pole will never hold.

Granted the attainment of the north pole, or that the attacks upon both poles can be carried on simultaneously, there is no greater believer or stronger advocate of the value and necessity for south polar exploration and the desirability of pushing it to the very pole itself than I.

I will note here but two other geographical feats of primary magnitude yet to be accomplished by the explorer.

The culminating peak of Asia remains yet to be won.

The culminating point of North America remains yet untrodden by human foot.

Large as has been the work done in the last nine years, the three salient resolutions of the sixth and seventh congresses regarding Antarctic exploration, map of the world on a uniform scale, and oceanography still hold good, and I hope to see them reaffirmed by this congress and supplemented by a fourth in regard to Arctic work.

It seems to me we ought not to deny the advantages to science of completing the exploration of the Arctic regions, where the features of an area almost as large as Australia—an area within which a valuable paper before this congress will indicate the probability of a new land—still remain unknown. And I sincerely hope that this congress will not ignore a field of investigation which, now that the flood tide of Antarctic exploration has somewhat spent itself, resumes its leading place, with five expeditions in the field or preparing to enter it.

The meeting of this congress in this country holds great possibilities of good for us as individual geographers by bringing us into direct contact with the work of our colleagues of other countries, who are hewing new paths and broadening old ones, and also for the people of our country. I earnestly hope that this session of the congress will prove a great and lasting stimulus to the interest of our people in geographic and allied research. We need a vigorous stirring up and awakening to the value of such work. With our abundant wealth, with our youth as a nation, with all our energy, push, ambition, and adaptability, yet as a country we have taken no part in large efforts in the geographical field for the past twenty years, but have allowed you, our friends across the water, to shame us by y ur splendid examples.

There is ample room for a larger force of active, able workers in the field of geographical investigation. Too much money is devoted to schools and libraries and too little to exploration and research, which furnish the facts for instruction in the schools and the material with which to fill the volumes in the libraries.

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coordinated plan, on a continuing basis; and this we should have, instead of frittering away time and money on a heterogeneous variety of investigations of narrow scope and often of small value.

That there are other fields of investigation of great value and promise within the domain of this congress goes without saying. Recognized specialists in these fields will bring them to the attention of the congress in their own masterly way.

I have spoken upon those things upon which I think and feel strongly.

In conclusion, I wish to express our obligations and acknowledgments to His Excellency President Roosevelt, that splendid, vigorous, typical American, who stands at our head to-day, the fearless, unhesitating man of magnificently wedded thought and action, who has graciously consented to head the congress;

To Baron Richthofen and his colleagues of the executive committee of the Seventh International Geographic Congress, for the way in which they have carried out the work intrusted to them by the congress;

To our distinguished foreign visitors and friends, who have devoted so much time and effort to be present;

To those who, prevented by circumstances from being present in person, have sent us most valuable papers;

To Professor McGee and his colleagues of the committee of arrangements; and

To Professor Davis and his colleagues of the committee on scientific programme, for their tireless efforts in behalf of this congress.

I can not close without a word or two expressing my deep appreciation of the honor shown me in electing me president of this distinguished organization, a position previously held by such eminent men as De Lessops, Sermoneta, Gobat, Markham, and Richthofen.

I have accepted the honor in the spirit in which I believe it was tendered, namely, as an expression of the sympathy and approval of the geographers and geographical associations of this country, and their interest in the work and aims with which I have been identified for the past fifteen years. As such, I greatly prize it.

Further, I deeply regret that insistent press of that same work has made it impossible for me to labor for the congress as I should have done.

The full and entire credit for the congress, both in scope and detail, is due to the able and tireless chairmen and members of the committees of arrangements and scientific programme and their associates, and to the delegates and members who have contributed the progeny of their brains to make it a success.

BERICHT DER GESCHÄFTSFÜHRUNG (EXECUTIVE COMMITTEE) ÜBER DIE ERLEDIGUNG DER BESCHLÜSSE DES VII. INTERNATIONALEN GEOGRAPHEN-KONGRESSES ZU BERLIN IM JAHR 1899

Den Beschlüssen der Kongresse zu Bern (1891) und London (1895) folgend hatte auch der Berliner Kongress in seiner Schluss-Sitzung bestimmt, dass seine Geschäftsführung bis zum nächsten Kongress in Funktion zu bleiben habe. Es erwuchs ihr die Aufgabe, in dieser Zwischenzeit die Ausführung der Beschlüsse des Kongresses in die Wege zu leiten und, soweit angängig, an deren Ausführung mitzuwirken.

In dem nachfolgenden Bericht, welchen die Geschäftsführung der Versammlung des Kongresses zu Washington unterbreitet, sind die Ergebnisse dieser Tätigkeit niedergelegt. Er knüpft an die einzelnen Kongressbeschlüsse, für welche hier die frühere Reihenfolge[a] beibehalten ist.

I. GEOGRAPHISCHE BIBLIOGRAPHIE

Auf Antrag des permanenten Bureaus des Londoner Kongresses (1895) wurde die Resolution angenommen:

> Der Kongress erklärt, dass die von der Berliner Gesellschaft für Erdkunde herausgegebene "Bibliotheca Geographica" als eine ausreichende internationale Bibliographie anerkannt wird.

Dieser Beschluss enthob die Geschäftsführung der weiteren Behandlung des in London gestellten Antrages. Doch ist Herr Otto Baschin, der Bearbeiter der als internationale geographische Bibliographie anerkannten "Bibliotheca Geographica der Gesellschaft für Erkunde zu Berlin" bei der Abfassung der seit dem letzten Kongress regelmässig erschienenen Jahrgänge bestrebt gewesen, noch mehr geeignete Mitarbeiter als früher, besonders für schwierigere Sprachen wie die slavischen, zu gewinnen. Es ist dadurch gelungen noch grössere Vollständigkeit zu erreichen, als bei den der Resolution zu Grunde liegenden Jahrgängen gefunden worden ist.

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[a] Verhandlungen des VII. Internationalen Geographen-Kongresses zu Berlin, Teil I, S. 307–322. Berlin, 1901.

2. WELTKARTE 1:1,000,000

Der VII. Internationale Geographen-Kongress erklärt die Herstellung einer einheitlichen Erdkarte im Maasstab von 1:1,000,000, deren Blätter durch Meridiane und Parallele begrenzt werden, für nützlich und wünschenswert. Die Geschäftsführung des Kongresses wird beauftragt, die erforderlichen Schritte für die Herstellung der Karte zu tun und zu diesem Behuf zunächst einen Netzentwurf ausarbeiten zu lassen.

Die Geschäftsführung hat bei der Inangriffnahme der ihr übertragenen Aufgabe die Schwierigkeiten zu gross gefunden, um zu energischer Durchführung ermutigt zu werden. Wenn auch die theoretischen Grundlinien der ideellen Weltkarte scharfsinnig festgestzt worden sind und es eine relativ einfache Aufgabe ist, an diesem oder jenem Punkt der Erde mit der Anfertigung einzelner momentan interessirender Kartenblätter nach individuellen Grundsätzen zu beginnen, so stellen sich doch dem Versuch der praktischen Durchführung eines grossen centralisirten und methodish einheitlich organisirten Unternehmens Hindernisse entgegen, welche kaum zu bewältigen schienen. Die Kongressleitung musste daher zu ihrem Bedauern darauf verzichten, sich ihres Auftrags zu entledigen. Der schon auf dem Geographen-Kongress in Bern (1891) von Penck für den Entwurf einer Weltkarte angeregte und bei jedem weiteren Kongress erörterte Maasstab 1:1,000,000 hat inzwischen wegen seiner bequemen Abrundung viel Einzelanwendung gefunden, ohne dass in diesen Versuchen Bruchstücke einer einheitlichen Weltkarte zu suchen wären.

Ansätze zu grösseren, wenn auch noch keineswegs allgemein umfassenden Plänen, liegen vor: in der "Carte au millionième" des französischen Service géographique de l'armée (seit 1900) und in der auf 132 Blätter berechneten, seit 1901 erscheinenden, vom englischen War Office herausgegebenen "Map of Africa." Andere Veröffentlichungen, bei denen derselbe Maasstab angewandt worden ist, waren von vorn herein nur auf Einzelgebiete berechnet. Dazu gehören: "Karte von Ostasien," von der königlichen preussischen Landesaufnahme; "Topographical Map of Japan" (15 Blätter), herausgegeben von der Imperial Geological Survey of Japan; "Carte du Maroc" (4 Blätter), von R. de Flotte de Roquevaine; ferner Karten von Korea (japanisch), Madagascar (französich) und anderen Ländern.

Da bei allen diesen Karten Projektion, Anlage, Methode, Höhenmaasstab, Transskription und Nullmeridian verschieden sind, sind sie in nähere Beziehung mit der Ausführung des Kongressbeschlusses nicht zu setzen.

Die Geschäftsführung von Berlin legt daher diese Angelegenheit unerledigt in die Hände des Kongresses zurück.

3. ANTARKTISCHE FORSCHUNG

Der Kongress nimmt von der für die Erforschung des Südpolar-Gebiets in den erstatteten Berichten vorgeschlagenen Arbeitsteilung Kenntnis und hegt die Erwartung, dass dadurch eine zweckmässige Grundlage für die internationale Kooperation bei den physisch-geographischen, geologischen, geodätischen und biologischen Forschungen gegeben ist. Für die meteorologisch-magnetischen Arbeiten erklärt der Kongress nähere Vereinbarungen für wünschenswert und beschliesst dafür die Einsetzung einer internationalen Kommission, deren Aufgabe es ist:

1. Den Umfang und die Forschungsmittel für die magnetisch-meteorologischen Arbeiten der Expeditionen selbst zu erörtern.
2. Die Organisation gleichzeitiger und korrespondirender Beobachtungen an geeigneten Orten ausserhalb des Südpolar-Gebiets zu erwirken.

Die Bildung der Kommission geschieht durch die Geschäftsführung des Kongresses.

Keiner der von dem vorigen Kongress beratenen und der Geschäftsführung überwiesenen Gegenstände ist in der Zwischenzeit so vollkommen erledigt worden wie dieser. Die damals geplanten antarktischen Expeditionen sind, um eine schwedische und eine schottische vermehrt, und durch eine argentinische Fahrt unterstützt, seitdem ausgeführt worden. Alle Expeditionen sind nach Lösung ihrer Aufgabe glücklich zurückgekehrt. Die einheitliche Gestaltung der Methoden magnetischer und meteorologischer Arbeiten, der Gebrauch gleichartiger Instrumente und gleicher Beobachtungszeiten wurden durch die Geschäftsführung zwischen Berlin und London vereinbart, und sie übernahm durch den Weg diplomatischer Vermittelung die Sorge für die internationale Organisation korrespondierender Beobachtungen an Observatorien beider Hemisphären über den Erdmagnetismus, und an Orten der Südhemisphäre über meteorologische Zustände und Vorgänge. Die Geschäftsführung hat sich dabei grossen Entgegenkommens allgemein zu erfreuen gehabt. Sie darf ihre Aufgabe als befriedigend gelöst betrachten.

4. ERDBEBENFORSCHUNG

Der Kongress spricht seine Zustimmung aus zu der Gründung einer internationalen seismologischen Gesellschaft und hält die Bildung einer permanenten Kommission für internationale Erdbebenforschung für wünschenswert.

Der Kongress beauftragt die Geschäftsführung des Kongresses mit der Bildung einer solchen Kommission.

Nach eingehenden Verhandlungen der Geschäftsführung mit dem Direktor der kaiserlichen Hauptstation für Erdbebenforschung zu Strassburg, Professor Dr. Gerland als Urheber der Resolution, und mit den zuständigen Behörden des Reiches und von Preussen wurde die permanente seismologische Kommission, deren Mitgliederzahl allmählich durch Zuwahl auf circa 50 aus 18 verschiedenen Ländern gestiegen war, auf diplomatischem Weg zur ersten internationalen Erdbebenkonferenz im April 1901 nach Strassburg einberufen. Der

Einladung hatten 31 Mitglieder der Kommission Folge gegeben. Als offizieller Vertreter der Geschäftsführung des Kongresses war Professor Dr. Hermann Wagner in Göttingen delegirt worden. Es wurde beschlossen, die bisherige Kommission, die ihren Zweck, die beabsichtigten Pläne möglichst bekannt zu machen und Interesse dafür zu erregen, erfüllt hatte, aufzulösen und eine neue kleinere zu bilden. Als Mitglieder dieser neuen permanenten seismologischen Kommission wurden im Einverständnis mit der Geschäftsführung des Kongresses die Herren Forel in Morges (Schweiz), Gerland in Strassburg, Helmert in Potsdam, v. Kövesligethy in Budapest, Lewitzky in Dorpat, v. Mojsisovics in Wien, Palazzo in Rom, mit Herrn Helmert als Vorsitzenden, gewählt.

Abgesehen von ihrer rein wissenschaftlichen Tätigkeit war das Ergebnis dieser Konferenz, die einstimmige Annahme des Vorschlags des japanischen Delegirten, statt einer internationalen seismologischen Gesellschaft eine internationale seismologische Staatenassociation zu gründen, in welcher, nach Art der internationalen Erdmessung, jeder einzelne Staat durch je eine Stimme vertreten sein soll. Ein solcher Modus schien den beabsichtigten Zwecken besser zu entsprechen; doch konnte die Annahme nur im Sinn vorläufiger Billigung geschehen. Dieses Ergebnis sollte den betreffenden Regierungen zu weiterer Beschlussfassung empfohlen werden. Ebenso wurde beschlossen, die deutsche Reichsregierung zu ersuchen, den von der Konferenz durchberatenen Entwurf dieses Vorschlags den auswärtigen Regierungen zu übersenden und dieselben anzuregen, ihrerseits das Zustandekommen der seismologischen Staatenassociation zu fördern.

Die deutsche Reichsregierung hat die ihr ausgesprochene Bitte erfüllt. Ihrer Einladung zu gemeinschaftlicher Arbeit auf einer zweiten internationalen Erdbebenkonferenz zu Strassburg im Juli 1903 wurde von den meisten Kulturstaaten durch Sendung offizieller Delegirter entsprochen. Ausser den Staaten des deutschen Reiches waren 20 fremde Staaten vertreten.

Auf dieser Konferenz ist eine Organisation für die internationale Erdbebenforschung geschaffen worden. Als Zweck der seismischen Staatenassociation wurde erklärt: Die Förderung aller derjenigen Aufgaben der Seismologie, welche nur durch das Zusammenwirken zahlreicher, über die ganze Erde verteilter Erdbebenstationen, ausgeführt werden können. Als hauptsächlichste Mittel hierzu sollen dienen: Beobachtungen nach gemeinsamen Grundsätzen, Experimente für besonders wichtige Spezialfragen; Gründung und Unterstützung seismischer Observatorien in Ländern, die der Beihilfe der Association bedürfen; Organisation eines Centralbureaus für Sammlung und Bearbeitung der Berichte aus den verschiedenen Ländern. Mitglieder der Association sollen die Staaten sein, welche ihren Beitritt erklären.

Das Centralbureau wurde durch gemeinsamen Beschluss mit der kaiserlichen deutschen Hauptstation für Erdbebenforschung zu Strassburg in solcher Weise verbunden, dass der Direktor derselben zugleich Direktor des Centralbureaus ist. Die Uebereinkunft wurde zunächst auf die Dauer von zwölf Jahren geschlossen, die mit dem 1. April 1904 begonnen hat.

ANMERKUNG.—Zur weiteren Information über den Gang der Verhandlungen ist ein besonderer Bericht von Herrn G. Gerland in Strassburg hier beigefügt.

5. SEENFORSCHUNG

L'étude des propositions Lampert et Halbfass, concernant une action internationale pour les recherches limnologiques, est renvoyée à une commission qui comprend MM. W. M. Davis, Cambridge, Mass.; A. Delebecque, Paris; F. A. Forel, Morges; Dr. L. v. Loczy, Budapest; Dr. H. Robert Mill, Londres; Dr. I. A. Palmén, Helsingfors; P. Pavesi, Pavia; Dr. E. Richter, Graz; I. de Schokalsky, St. Pétersbourg; Dr. W. Ule, Halle.

M. Forel est chargé de présider à cette commission qui fera rapport à la prochaine session du Congrès international de géographie.

Nach Mitteilung von Herrn Forel ist es ihm trotz wiederholter eigener Bemühungen nicht gelungen, eine erspriessliche Tätigkeit der Kommission herbeizuführen. Doch sind, zum Teil in Folge der durch den Kongress gegebenen Anregung, vielfach limnologische Arbeiten seit dem Jahre 1899 ausgeführt worden. Als solche sind zu nennen:

1. Die Morphometrie der Seen ist in sehr vielen Ländern mit grosser Sorgfalt und nach im Allgemeinen ähnlichen Methoden betrieben worden.

2. Gleichzeitige Untersuchungen der Wärmeverteilung wurden im Jahr 1900 im Genfer See, Loch Katrine, Wettern-See, Mjösen-See, Ladoga-See und Enare-See unternommen.[a]

3. Für das Studium der Seiches (Seespiegel-Schwankungen) ist in der Schweiz, Deutschland, Italien, Oesterreich, England, Russland und Japan eine Gleichmässigkeit in den anzuwendenden Methoden und Instrumenten (Sarasin'sches Limnomètre enregistreur portatif) angenommen worden; es steht zu erwarten, dass auch Norwegen und die Vereinigten Staaten von Amerika sich diesen Bestrebungen anschliessen werden.

4. Gegenwärtig arbeitet man am Achensee von Seiten Deutschlands und Oesterreichs an einer Einigung in der Bezeichnung und Definition der Farben der Seen auf Grund gemeinsamer exakter Beobachtungen.

5. Eine Zusammenfassung der gesammten limnologischen Literatur plant die Lake Survey in Schottland (Challenger Office) unter der

[a] S. Pettersson, im Bihang till K. Svenska Vetenskaps-Akademiens Handlingar, Band 28, Häftet II, No. 2, Stockholm, 1902; und Forel, in Archives des sciences physiques et naturelles, XII, Genf, 1901.

Leitung von Sir John Murray. Eine vorläufige Zusammenfassung der morphometrischen Verhältnisse der europäischen Seen gab W. Halbfass in der Zeitschrift der Gesellschaft für Erdkunde zu Berlin 1903–4. Eine Ausdehnung auf alle Seen der Erde ist von demselben Verfasser in Aussicht genommen.

6. NOMENKLATUR DES MEERESBODENS

Der Kongress wolle eine internationale Kommission für die suboceanische Nomenklatur einsetzen, mit dem Auftrag, bis zum Zusammentritt des nächsten Kongresses die Ausarbeitung und Veröffentlichung einer berichtigten Tiefseekarte des Weltmeeres zu veranlassen.

Die Geschäftsführung hat die vom Kongress eingesetzte Kommission zu einer Sitzung auf den 15. April 1903 nach Wiesbaden zuammenberufen. Der Einladung sind gefolgt die Herren: Fürst von Monaco, Mill, Thoulet, Pettersson, Supan, Krümmel. Die Beratungen fanden unter dem Vorsitz des Fürsten von Monaco am 15. und 16. April statt und hatten nach einem Bericht des Herrn Krümmel die folgenden Ergebnisse:

1. Es wurde den von Professor Krümmel auf dem Berliner Kongress am 30. September 1899 vorgetragenen und im zweiten Band der "Verhandlungen des VII. Internationalen Geographen-Kongresses" (S. 379) abgedruckten Thesen zugestimmt. Ferner wurde die von Professor Supan in Petermanns Mitteilungen 1899, Tafel 12, veröffentlichte Karte der Meerestiefen als Grundlage für die neue Nomenklatur angenommen. Die Herren Supan und Krümmel wurden beauftragt, genaue Definitionen der hauptsächlichsten Kategorien der submarinen Bodenformen in deutscher Sprache auszuarbeiten und den Entwurf dieser Terminologie an die Herren Thoulet und Mill zur Uebersetzung in die französische und englische Sprache zu übersenden.

2. Der Plan eines von Herrn Thoulet entworfenen grösseren Atlas der Meerestiefen in 32 Blättern wurde gebilligt. Die Karte soll in 24 Sektionen das Gebiet zwischen 72° nördlicher und südlicher Breite in Merkator-Projektion mit dem äquatorialen Maasstab von 1:10,000,000, und je 4 Sektionen für die Polarräume in Polarprojektion, umfassen. Ferner soll eine beschränkte Zahl von Spezialkarten für besonders wichtige Meeresteile in Merkator-Projektion im Maasstab von 1:1,000,000 (am Äquator) dem Atlas beigegeben werden. Als Beispiele legten Herr Thoulet eine in Handzeichnung hergestellte Sektion in 1:10,000,000 aus dem nordatlantischen Ocean (zwischen 0° und 45° nördlicher Breite), und der Fürst von Monaco eine nach seinen neuesten Lotungen von Thoulet bearbeitete und soeben im Druck erschienene Karte der Azoren (1:1,000,000) vor. Zusammengesetzt werden die 24 Blätter der grösseren Karte eine Fläche von 2 zu 4 Metern bedecken. Auch für die Herstellung dieser grösseren Karte bewies der Fürst von Monaco ein so lebhaftes Interesse, dass deren Erscheinen in absehbarer Zeit als gesichert betrachtet werden darf.

Diesem Bericht von Herrn Krümmel ist hinzuzufügen, dass, in Erledigung des Beschlusses zu 1, Professor Supan in Petermanns Mitteilungen 1903, S. 151 ff., die "Terminologie der wichtigsten unterseeischen Bodenformen" im Auftrage der Kommission veröffentlicht.

Betreffend Punkt 2 ist, nach dem Bulletin du Musée océanographique No. 4, bereits zu Anfang dieses Jahres der Entwurf einer

allgemeinen Tiefenkarte der Oceane der Pariser Akademie der Wissenschaften vorgelegt worden, deren Herstellung auf Kosten des Fürsten von Monaco geschieht.

Die Resolution ist hiermit erledigt.

7. NOMENKLATUR DER PFLANZENFORMATIONEN

Der VII. Internationale Geographen-Kongress beauftragt die Geschäftsführung, aus den in Berlin und Umgegend domicilirten Biogeographen eine vorbereitende Kommission zu wählen und dieselbe zu ersuchen, behufs Einführung einer einheitlichen Nomenklatur der Pflanzenformationen ein einfaches System auszuarbeiten, den vorläufigen Entwurf durch die in- und ausländischen Fachgenossen begutachten zu lassen, und den mit Berücksichtigung der Antworten umgearbeiteten definitiv festgestellten Entwurf dem nächsten Internationalen Geographen-Kongress zur Beschlussfassung vorzulegen.

Diese Frage hat bisher noch nicht ihre Erledigung finden können.

8. INTERNATIONALE KARTOGRAPHISCHE VEREINIGUNG

Der Kongress erklärt die Begründung einer "Association cartographique internationale" für zweckmässig und beauftragt eine Kommission mit der Vorbereitung zur Gründung einer solchen.

Von den drei Delegirten der genannten Kommission, den Herren Tillo, Steinmetz, und F. Schrader, wurde sehr bald nach dem Schluss des Berliner Kongresses der eigentliche Urheber dieses Planes, General-Leutnant von Tillo in St. Petersburg, seiner äusserst nutzbringenden und reichen Tätigkeit duch den Tod entrissen, während General-Leutnant Steinmetz, Chef der preussichen Landesaufnahme in Berlin, aus Gesundheitsrücksichten, die ihn auch zum Abschied aus seiner Dienststellung nötigten, seinen Austritt aus der Kommission erklärte. In Folge dessen ist letztere nicht in Tätigkeit getreten.

9. REGELN FÜR GEOGRAPHISCHE NAMEN

1. Die einheimischen Namen sind nicht nur dort, wo dies als selbstverständlich gilt, sondern auch in der Südsee, beizubehalten und deshalb mit der grössten Sorgfalt festzustellen.
2. Wo einheimische Namen nicht existiren oder noch nicht mit Sicherheit ermittelt sind, sind bis auf weiteres die von den ersten Entdeckern gegebenen Namen anzunehmen.
3. Die willkürliche Änderung historischer, längst vorhandener, allgemein bekannter und in der Wissenschaft anerkannter Namen muss als pietätlos und für die Wissenschaft und den Verkehr verwirrend bezeichnet und mit allen Mitteln bekämpft werden.
4. Unrichtige und willkürlich neu gebildete Namen sind je eher desto besser durch die einheimischen oder sonst berechtigten zu ersetzen.

Diese Regeln sind zwar noch nicht durchgedrungen, doch werden sie von Reisenden und in wissenschaftlichen Werken mehr als früher befolgt. Ihre Veröffentlichung als Kongressbeschluss in Zeitschriften

ist vielleicht von Einfluss darauf gewesen. Wenn ausserdem in den letzten Jahren vielfach eine amtliche Festlegung geographischer Namen stattgefunden hat, so hat sie häufig gelehrt, welch geringen Einfluss die Wünsche internationaler geographischer Kongresse auf die Entschliessungen der Staatsregierungen haben.

10. QUELLENANGABE BEI KARTENZEICHNUNG

Il serait désirable—

(*a*) Que, dans les relations de voyages, la publication de matériaux géographiques soit accompagnée de détails sur la méthode des levés, les instruments employés, leur vérification, le calcul des positions astronomiques avec leurs erreurs probables et le mode d'utilisation de ces données pour la construction de la carte.

(*b*) Que les cartes publiées par des savants ou par des institutions géographiques gouvernementales ou privées soient accompagnées de notices donnant au moins l'énumération des données principales employées pour la construction des cartes et indiquant les parties des cartes plus ou moins documentées.

Diese Anregung hat den gewünschten Erfolg noch nicht gehabt. Dem ersten Wunsch wird zwar in Werken von wissenschaftlichem Charakter im allgemeinen Rechnung getragen; der zweite wird noch viel zu wenig berücksichtigt. Ein erneuter Ausdruck dieser Wünsche seitens des Kongresses in Washington dürfte daher von Nutzen sein.

11. AUSDRUCK FÜR DEN MAASSTAB VON KARTEN

Der VII. Internationale Geographen-Kongress spricht den dringenden Wunsch aus, dass auf sämtlichen Karten, auch in den Ländern, die sich des englischen oder russischen Maasses bedienen, neben dem graphischen Maasstab auch das Reduktionsverhältnis in der üblichen Bruchform $1:x$ angegeben und das letztere auch in den Verzeichnissen der Land- und Seekarten beigefügt werde, und beauftragt die Geschäftsführung des Kongresses, die Regierungen, die geographischen Gesellschaften und die kartographischen Anstalten von diesem Wunsch in Kenntnis zu setzen.

Der Nutzen der Stützung dieses aus der Redaktion von Petermanns Mitteilungen stammenden Antrags durch den Kongress und der weiten Verbreitung der Resolution ist unverkennbar. Insbesondere ist in maasgebenden englischen Zeitschriften die Beigabe des Verhältnisses $1:x$ neben der früher allein üblichen von "x miles to 1 inch" gebräuchlich geworden. In Amerika ist man mehrfach noch darüber hinausgegangen, indem die Beisetzung des Reduktionsverhältnisses von selbst zur direkten Anwendung des Decimalsystems in den Kartenmaastäben geführt hat.

12. DECIMAL-EINTEILUNG

Le VII. Congrès international de géographie exprime le vœu de voir un système uniforme employé dans toutes les recherches et les discussions géographiques; et il recommande à cet effet l'usage du système métrique des poids et mesures, ainsi que l'emploi de l'échelle thermométrique centigrade.

Tout au moins est-il désirable qu'on ajoute aux indications des thermomètres de Fahrenheit et de Réaumur leur traduction conformément à l'échelle de Celsius.

Auch in dieser Frage, welche tiefer als die vorige in alt angestammte gewohnheitsmässige Handhabung alltäglicher Begriffe und Vorstellungen eingreift, ist die erneute Anregung zur Herstellung internationaler Einheitlichbkeit und Verständigung nicht ohne Erfolg geblieben. Wenn auch das metrische System in Maass und Gewicht nur langsam, und wesentlich durch die Tore wissenschaftlicher Arbeit auf den Gebieten der reinen Chemie und Physik, seinen Einzug in den Bereich allgemeinerer wissenschaftlicher Arbeit hält, so ist es doch zuweilen schon bis in die Geophysik und die Geographie eingedrungen. In England hat sich eine besondere Gesellschaft "die Decimal Association" der Angelegenheit angenommen. Der Commonwealth of Australia betraute eine Kommission mit der Prüfung der Angelegenheit. Von russischen Bestrebungen in dieser Richtung ist nichts bekannt.

13. ZEIT- UND KREISTEILUNG

Le Congrès exprime le désir de voir conservée la division du temps telle qu'elle existe, ainsi que celle de la circonférence en 360 degrés, en admettant cependant qu'on puisse étudier ultérieurement un nouveau système de division d'angle.

Il ne présente pas d'objections à l'emploi de la division décimale du degré en cas utile.

In dieser Frage ist die Aufstellung einer gegenteiligen Äusserung seit dem Berliner Kongress nicht wahrgenommen worden.

14. MEERESFORSCHUNG

Der VII. Internationale Geographen-Kongress erklärt die Beschlüsse der Stockholmer Konferenz zur Erforschung der Meere, von Juni 1899, für so wichtig auch für die Förderung der Oceanographie im allgemeinen, dass er auch seinerseits den beteiligten Regierungen dringend die Durchführung der Beschlüsse in ihrem vollen Umfang empfiehlt.

Die Frage der Meeresforschung hat sich nach der letzten Versammlung des Internationalen Geographen-Kongresses äusserst günstig entwickelt. Nachdem auf den Konferenzen für internationale Meeresforschung in Stockholm (1899) und in Christiania (1901) von den an der Untersuchung der nordeuropäischen Meere besonders interessirten Staaten das Programm für das Zusammenarbeiten festgestellt worden war, konstituirte sich im Juli 1902 in Kopenhagen der Central-Ausschuss für die internationale Meeresforschung. Er setzte sich zunächst zusammen aus Vertretern der Staaten Dänemark, Deutschland, England, Finland, Holland, Norwegen, Russland und Schweden. Belgien trat im Jahr 1903 hinzu, während Frankreich seine Teilnahme ablehnte. Das Centralbureau, das seinen Sitz in Kopenhagen hat, giebt alle Veröffentlichungen des Central-Ausschusses heraus und vermittelt den Verkehr zwischen den einzelnen National-Instituten und den Spezial-Kommissionen. Ausserdem wurde in Christiania ein internationales

Laboratorium, mit Dr. Fritjof Nansen als Leiter und zwei Assistenten, für chemische und physikalische Untersuchungen, errichtet. Dieses Institut soll Beobachter für die einzelnen nationalen Institute heranbilden, Instrumente nachprüfen, chemische und Gas-Analysen ausführen, und dadurch die Genauigkeit und Zuverlässigkeit der Beobachtungen erhöhen. Die Untersuchungen geschehen von den beteiligten Uferstaaten: in der Ost- und Nordsee, im nordatlantischen Ocean, und im Eismeer bis zur Bären-Insel und längs der Murman-Küste. Die Arbeiten sind teils oceanographischer teils biologischer Natur. Die oceanographischen sollen durch viermal im Jahr auszuführende Simultan-Beobachtungen auf den Beobachtungsschiffen der beteiligten Nationen ausgeführt werden; die Beobachtungen sollen sich auf Temperatur und Dichtigkeit des Wassers und auf das Plankton beziehen. Jeder Nation ist ein bestimmtes Beobachtungsgebiet zugeteilt. Ausserdem sollen auch von festen Stationen aus, wie von Leuchtschiffen, oder von den Schiffen der regelmässig verkehrenden Dampferlinien, Beobachtungen angestellt werden. Die biologischen Arbeiten sollen besonders der Förderung der Fischerei dienen und sich hauptsächlich mit der Lösung zweier Probleme befassen:

1. Der Wanderungen des Kabeljaus und des Herings.

2. Der Überfischung der von Schleppnetzfischern besuchten Teile der Nordsee. Für jedes Problem ist eine Kommission eingesetzt, an deren Spitze ein Geschäftsführer steht. Über die bisher ausgeführten Arbeiten berichten die vom Central-Ausschuss herausgegebenen "Rapports et procès-verbaux," Vol. I, und das "Bulletin des Résultats," etc., année 1902–3.

15. SAMMLUNG VON MATERIAL ÜBER TREIBEIS

In Anerkennung des grossen wissenschaftlichen und praktischen Interesses, welches darin liegt, die jährliche Ausdehnung, Form und Menge des Treibeises zu kennen, richtet der Kongress an die hydrographischen und meteorologischen Institute derjenigen Länder, welche dort Schiffahrt treiben, wo Eis vorkommt, die dringende Bitte, mittels internationalen Zusammenwirkens die Erwerbung möglichst erschöpfender Aufschlüsse über das Treibeis zu erstreben und deren einheitliche Verarbeitung durch eine Centralstelle zu fördern. Auf Grund der in dieser Hinsicht bereits vorliegenden Arbeiten erklärt der Kongress das dänische meteorologische Institut in Kopenhagen als die geeignetste Centralstelle zur Sammlung und Verarbeitung des Materials über das Treibeis in den nördlichen Meeren und bittet deshalb die betreffenden anderen Institute:

1. Schiffskommandanten und Schiffsführer zur Mitteilung von Beobachtungen über das Treibeis zu bewegen.

2. die Schiffe mit Formularen zu versehen, welche von dem dänischen meteorologischen Institut vorher zugestellt werden.

3. die Schiffskommandanten und Schiffsführer zu veranlassen, diese Formulare auszufüllen und sogleich einzusenden, wenn sie einen in Postverbindung stehenden Hafen erreichen. Die Einsendung kann entweder direkt an die Centralstelle oder durch Vermittelung der betreffenden Institute erfolgen.

Dem Ansuchen der Geschäftsführung des Kongresses an das dänische meteorologische Institut, dem Beschluss des Kongresses entsprechend als Centralstelle zur Sammlung und Verarbeitung des Materials über das Treibeis in den nördlichen Meeren zu dienen, wurde seitens des Instituts in entgegenkommendster Weise Folge gegeben. Auch erklärten sich zur Mitarbeit durch Einsendung des bei ihnen eingegangenen Beobachtungsmaterials folgende andere Behörden und Institute bereit: Das russische Marine-Ministerium, das Hydrographic Office in Washington, das Meteorological Office in London, das norwegische meteorologische Institut in Christiania, die meteorologische Centralanstalt in Stockholm, der königliche grönländische Handel in Kopenhagen und die deutsche Seewarte in Hamburg.

Das in Jahresabschnitten vom dänischen meteorologischen Institut verarbeitete Material wird in den "Isforholdene i de arktiske Have" veröffentlicht; die Jahrgänge 1900 bis 1903 liegen bereits vor.

16. BEVÖLKERUNGSZAHLEN FÜR LÄNDER OHNE CENSUS

The Seventh International Geographical Congress recognizes the desirability of obtaining the data for a more exact estimate than now exists of the population of countries in which no means of taking a regular census exists, and instructs the executive committee of the congress to bring the matter to the notice of such governments as have foreign possessions, either directly or through the medium of geographical societies. In doing so attention should be drawn to the scheme proposed by Doctor Kiaer, of the Norwegian Statistical Bureau. The executive committee of the congress might also communicate with the committee on the subject appointed by the International Statistical Congress held in Christiania.

Das internationale statistische Institut hat sich der Erledigung dieser Frage ernstlich angenommen, indem es kleine Kommissionen zur Durchberatung aufzustellender Fragebogen ernannte. Auch wurde über die Angelegenheit in den Tagungen des Instituts zu Budapest 1901, sowie zu Berlin 1903, eingehend verhandelt und in der letzten Versammlung die vom dänischen Statistiker Marcus Rubin ausgearbeiteten Formulare zum Beschluss erhoben. Zur allgemeinen Kenntnis sind diese durch Veröffentlichung in Petermanns Mitteilungen 1903, S. 277 ff., gelangt.

17. STATISTISCHE GRUNDKARTEN

Der VII. Internationale Geographen-Kongress erklärt die Herstellung bevölkerungs-statistischer Grundkarten für wünschenswert; er empfiehlt Fachmännern, sowie den statistischen Ämtern und Kongressen die weitere Untersuchung dieser Frage.

Diese in erster Reihe Fachmännern zur weiteren Untersuchung vom Kongress empfohlene Frage der Methodik der kartographischen Darstellung der Bevölkerungsdichte ist Behandlungsgegenstand einer grossen Reihe von Schriften geworden.[a]

[a] S. geographisches Jahrbuch 1903, S. 402 ff.

18. KARTEN VORGESCHICHTLICHER WOHN- UND GRABSTÄTTEN

Der VII. Internationale Geographen-Kongress erklärt die Herstellung solcher Karten für höchst wünschenswert, in denen die Wohn- und Begräbnisstätten der Völkerschaften aus der sogenannten vorgeschichtlichen Zeit mit möglichster Auseinanderhaltung der Perioden ersichtlich sind. Er lenkt die Aufmerksamkeit des in Paris im Jahr 1900 zusammentretenden archäologischen und prähistorischen Kongresses auf diese Fragen und überlässt diesem die Einsetzung einer internationalen Kommission.

Diese Angelegenheit ist durch Überweisung an die archäologischen und prähistorischen Kongresse erledigt worden.

19. EXPEDITION ZUR AUFSUCHUNG LEICHHARDTS

Nach den vor wenigen Tagen eingetroffenen Mitteilungen des kaiserlichen General-Konsuls in Sydney (Neu-Süd-Wales) Herrn Kempermann, trägt man sich in den Kolonien Australiens mit der Absicht, eine Expedition, welche nur der Aufsuchung der Überreste der gänzlich verschollenen Expedition Dr. Leichhardts dienen soll, zu entsenden. Obgleich nun beinahe 52 Jahre seit dem Abgang der Expedition verflossen sind, sollte die Hoffnung, wenigstens Spuren jener Expedition aufzufinden, die der Aufklärung des Schicksals derselben dienen können, nicht aufgegeben werden. Der in der unmittelbaren Nähe der Heimat des verschollenen Gelehrten versammelte VII. Internationale Geographen-Kongress ergreift gern die Gelegenheit seine Sympathie mit den Zielen der geplanten Aufsuchungs-Expedition auszusprechen und derselben einen vollen Erfolg zu wünschen.

Bisher ist von einem Resultat nichts bekannt.

Im Mai 1904 ist von Adelaide aus eine Expedition unter Captain Barclay aufgebrochen, die bei der beabsichtigten Durchquerung Australiens auch die von Leichhardt berührten Gegenden besuchen will. Vielleicht gelingt es jetzt, Spuren von ihm und seiner Expedition aufzufinden.

20. TRANSKRIPTION

Der Congress spricht den Wunsch aus, dass die Frage der Transskription geographischer Namen auch auf dem künftigen Internationalen Geographen-Kongress zur Beratung gestellt werde.

Entscheidende oder auch nur fördernde Schritte sind betreffs Einführung einer einheitlichen Transskription seit der Berliner Versammlung nicht geschehen. Auch die Geschäftsführung ist nicht in der Lage gewesen zu ihrer Weiterführung beizutragen.

Die Geschäftsführung des VII. Internationalen Geographen-Kongresses zu Berlin,

Frhr. v. RICHTHOFEN,
Vorsitzender.

BERLIN, *Juli 1904.*

NOTE SUR LA COMMISSION PRÉPARATOIRE D'UNION CARTOGRAPHIQUE INTERNATIONALE ÉTABLIE PAR LE CONGRÈS GÉOGRAPHIQUE DE BERLIN

Sur la proposition du regretté général de Tillo, le dernier Congrès international de géographie, réuni à Berlin en 1899, vota le principe de la fondation, ou pour mieux dire de la préparation d'une Union cartographique internationale, analogue aux organisations similaires qui fonctionnent pour le perfectionnement de la géodésie, de la géologie, des poids et mesures, de la carte du ciel, etc.

Cette commission fut au début composée de trois membres, M. le général de Tillo, directeur de l'état-major russe, M. le général de Steinmetz, directeur de l'état-major prussien, et l'auteur de ces lignes.

Pour que ce dernier soit appelé à rendre compte au Congrès international de Washington du modeste commencement d'action qui a suivi la décision du congrès de Berlin, et de l'état actuel de la question, il a fallu la mort prématurée du président de la commission, M. le général de Tillo, et la démission d'un deuxième membre, notre collègue M. le général de Steinmetz. C'est ainsi que, seul survivant en quelque sorte, il a dû s'imposer le devoir de présenter le bref compte-rendu et les quelques considérations qui suivent.

Avant d'aller plus loin, il y a lieu tout d'abord de porter à la connaissance du congrès la nomination, faite au cours de l'année 1900, de M. le général Rikatchev, directeur de l'observatoire d'astronomie physique et vice-président effectif de la Société de géographie de Saint-Pétersbourg, par les deux membres restants de la commission, en remplacement de M. le général de Tillo, opérée en vertu du droit de cooptation attribué à la commission par le congrès qui l'avait nommée. Cette nomination avait pour but de conserver un représentant à la science russe, qui avait pris en quelque sorte l'initiative de la proposition, par une brochure remarquable de M. le général de Tillo, présente à toutes les mémoires.

En outre, la présence de M. le général Rikatchev et de M. le général de Steinmetz à Paris, au mois de juin 1900, permit à la commission de se réunir le 24 juin, en s'adjoignant à titre amical et officieux un certain nombre de géographes et de cartographes amenés dans

cette capitale par l'exposition. Parmi ceux qui avaient envoyé leur adhésion ou qui purent prendre part à cette réunion tenue au domicile privé de M. Schrader, il faut citer MM. le baron Hulot et Gauthiot, secrétaires généraux des deux sociétés de Géographie et de Géographie commerciale, M. Emm. de Margerie, M. le major Held, directeur du Bureau topographique de Berne, M. le colonel Rodrigo Valdes, directeur des travaux de la carte générale du Méxique, M. Camille Guy, directeur de la cartographie au Ministère des colonies, aujourd'hui gouverneur du Sénégal, etc.

Dans cette réunion amicale, il n'était pas question, à peine est-il besoin de le dire, de régler ou de codifier les conditions d'existence de l'Union. La conversation fut un simple échange de vues, sans autre but ni résultat que d'éclairer la pensée de chacun. Tous les membres présents tombèrent d'accord sur la nécessité d'établir avant tout une base de départ et de s'informer de l'état actuel de la science cartographique avant de rechercher ce qu'il faudrait y ajouter. Et tous pensèrent que l'œuvre devait commencer par l'établissement d'un inventaire comparé des études géographiques, un bilan de l'état des connaissances pour chaque partie du globe, bilan établi de la façon la plus simple, sous un aspect à la fois graphique et explicatif, avec mention de l'origine, de l'importance des œuvres, des modes ou degrés d'exploration, des échelles, projections, unités de mesure employées, etc.

Pour la préparation de cette sorte d'inventaire, il paraissait tout d'abord indiqué de faire appel aux administrations ou aux gouvernements des différents pays. Mais il devint bientôt évident que ce moyen ne serait suivi d'aucun résultat d'ensemble. Aux premières démarches de M. le général de Tillo, et malgré sa haute position personnelle, le gouvernement russe avait répondu par un refus très net et définitif. M. le général de Steinmetz n'était pas certain d'un meilleur accueil auprès du gouvernement de son pays. M. le major Held n'osait pas espérer une solution plus favorable, malgré les dispositions plus libérales de la Suisse, en qualité de pays neutre. Si le Service cartographique des colonies françaises était disposé à entrer dans la voie indiquée ce ne pouvait être sans certaines réserves qu'il suffit de mentionner pour que leur existence inévitable apparaisse clairement à tous. En Angleterre, nous étions assurés de rencontrer dans les milieux officiels les difficultés qui apparaissent chaque fois qu'il est question d'une unification touchant d'une manière quelconque aux unités de mesure. Sans doute, l'écrivain de ce rapport a trouvé des dispositions plus favorables en principe aux Etats-Unis où il a séjourné quelque temps en 1902, mais les républiques de l'Amérique du Sud auxquelles il s'est adressé au cours d'un voyage plus récent (1903–4) ne lui ont donné aucune réponse, ou ne lui ont témoigné que peu de dispositions à entrer officiellement dans

une Union cartographique—la République Argentine par exemple. La collaboration initiale des Etats intéressés, même de ceux où le niveau scientifique est le plus élevé, n'est donc guère dans les choses probables, et ce peu d'empressement ne doit pas surprendre. La cartographie officielle est, par nature, obligée à certaines restrictions inévitables, et que les préoccupations de défense rendent parfois légitimes. Par cela même elle ne peut guère demander que des profanes ou des étrangers possèdent les secrets ou connaissent les côtés confidentiels des productions d'Etat. Je me permettrai même d'ajouter que dans les pays où ces productions sont particulièrement faibles, et où par conséquent la collaboration serait le plus utile pour les relever, la nécessité de leur conserver une réputation suffisante sera une raison pour ne pas initier le monde de la science aux secrets de leur faiblesse. Enfin, pour les colonies en formation, pour les pays dont l'expansion se continue, plus ou moins évidente ou latente, comme l'Empire russe, ou même pour certaines républiques sudaméricaines, des litiges de frontière viendraient encore ajouter une difficulté à l'accord préalable.

Telles sont les diverses raisons qui avaient amené les membres de la réunion à penser que la collaboration directe des Etats à la création d'une Union cartographique internationale ne pouvait être obtenue que si cette création était d'abord préparée par un autre genre d'organismes qui pût en démontrer la nécessité urgente. Il leur parut que cet ensemble d'organismes pourrait être trouvé dans les principales sociétés de Géographie d'Europe et d'Amérique, en y joignant quelques associations similaires des autres parties du monde, qui ne sont, à vrai dire, qu'un prolongement des unes ou des autres. Telle fut l'opinion dominante qui résulta de la réunion préparatoire, et que l'écrivain de ces lignes présente au congrès, sans lui donner aucun autre caractère que celui d'une opinion. Les grandes sociétés de géographie, en effet, rassemblent dans leurs comités directeurs un grand nombre de personnalités éminentes des pays où elles siègent, et présentent ce caractère particulier de tendre, par la nature même de leurs travaux, à établir entre elles des rapports de plus en plus intimes. Les congrès internationaux en sont la preuve évidente. Sans doute ces sociétés ont plutôt pour objet la géographie que la cartographie, mais parmi les branches de l'étude de la terre, la cartographie a plus d'une fois tenu sa bonne place dans les travaux des congrès. Le projet d'une carte du monde au 1 1,000,000 proposée et élaborée par notre collègue A. Penck, de Vienne, et qui a été discuté dans plusieurs congrès successifs, n'était-il pas en quelque sorte le germe de l'Union cartographique internationale projetée?

Il y a lieu en effet de distinguer deux parties distinctes dans la création de l'Union cartographique. Si la question paraît mûre à quelques esprits spécialement préparés, ces esprits sont peu nombreux,

à moins que la question n'ait fait de bien grands progrès depuis 1899, par suite de ce travail inconscient que toute idée juste, une fois émise, provoque dans les cerveaux.

Mais en 1899 il n'en était pas encore ainsi. L'idée qu'il est nécessaire, et même indispensable, que l'étude de la terre soit reliée par un organisme général, et que ce rouage doit être ajouté à notre civilisation industrielle et fragmentaire pour la transformer en une civilisation scientifique et générale, cette idée commence à peine à pénétrer dans les couches supérieures d'une élite intellectuelle. Je désirerais me tromper, et peut-être le congrès de Washington révélera-t-il un état d'esprit plus avancé. Dans ce cas, la proposition dont j'ai reçu communication de M. J. de Schokalski, et dont ce savant a adressé l'original au congrès, pourrait avoir quelque chance de réussir et hâterait l'organisation de l'Union cartographique universelle. Mais il paraît plus probable qu'il faudra commencer par ailleurs que par une action diplomatique sur les pouvoirs nationaux et sur les grands ateliers de cartographie officielle et défensive, et que ceux-ci, sur la collaboration desquels nous pourrions compter dans l'avenir, consentiraient à suivre un mouvement déjà préparé, bien plus volontiers qu'ils ne le prépareraient eux-mêmes.

C'est donc, dans ce cas, par une action combinée des grandes sociétés de géographie qu'il y aurait lieu, nous semble-t-il, de débuter, et cette action devrait, toujours d'après l'opinion personnelle de celui qui écrit ces lignes, se porter tout d'abord sur une sorte d'inventaire des travaux cartographiques existants. Cet inventaire une fois fait, les richesses, les lacunes ou les désiderata apparaîtraient bien plus nettement. Or les bases de cet inventaire détaillé ne seraient pas bien difficiles à établir; elles existent même dans une certaine mesure, ainsi qu'il est dit un peu plus loin, en tableaux graphiques sur lesquels ont été porté au fur et à mesure de leur apparition tous les documents nouveaux depuis plus de vingt ans.

Il suffirait de joindre à de tels tableaux synoptiques la mention des cartes officielles et fondamentales qui forment comme la base de la connaissance cartographique des principaux pays déjà bien étudiés, pour établir une sorte d'état récapitulatif de la cartographie. L'établissement de ce travail pourrait former le programme primitif de la commission remaniée et complétée par le congrès de Washington. Celui qui écrit ces lignes se met bien volontiers à la disposition de la commission pour l'aider à ce travail dans la mesure de ses forces et de son dévoûment, si elle juge à propos de lui demander sa collaboration. Il demande la permission d'exposer très brièvement, à la suite de ces lignes, et après MM. de Tillo et Habenicht, les motifs qui lui paraissent rendre de plus en plus urgent la création de l'Union cartographique universelle.

A la prise de possession de notre planète par la civilisation de l'Europe et par celle de l'Amérique, qui en est le prolongement, correspond dans tous les domaines de l'activité humaine un état de choses nouveau, dont le dénoûment fatal apparaît chaque jour plus inévitable. A mesure que la rapidité et l'intensité des mouvements ou des rapports humains s'accroissent, réduisant pour ainsi dire d'heure en heure la part nécessaire du temps et de l'espace, les contacts entre les hommes deviennent de plus en plus étroits. Les uns s'en réjouissent et prédisent la fusion prochaine de l'humanité, les autres s'en attristent et s'efforcent de relever les limites morales ou intellectuelles entre les diverses fractions de la race humaine; qu'on nous permette de dire que ces deux manières de voir ou de sentir, légitimes chacune dans une mesure, ne pourront modifier en rien la marche des choses. Chaque rail posé, chaque fil électrique tendu, chaque acheminement vers la conquête de l'air, déchire une maille du vieux réseau de coutumes ou de sentiments dans lequel nous avons grandi, et prépare, par cette déchirure jointe à des milliers d'autres, un état de choses qui différera demain de celui d'hier, après-demain de celui de demain. Nul ne peut le nier, nul ne peut s'y opposer sans folie. Les considérations politiques qu'on peut échafauder à ce sujet ne doivent pas pénétrer ici; c'est uniquement le point de vue scientifique, la question des rapports de l'homme et de la terre qui doit nous préoccuper en ce moment, et c'est dans ce domaine que je voudrais faire avec vous, mes chers collègues, une excursion de quelques minutes.

Cette prise de possession de la terre, qui caractérise le XIX^e siècle, se présente sous deux aspects: c'est d'abord un rapprochement matériel des sociétés humaines, dû à l'accroissement de nos organes de locomotion ou de transport; c'est ensuite, comme conséquence, une poussée générale vers les parties de la terre, qui, moins accessibles jadis, nous paraissent aujourd'hui devoir entrer, de gré ou de force, dans l'orbite morale, intellectuelle, industrielle ou commerciale de l'Europe. Permettez-moi de laisser de côté toute espèce de commentaires et de constater le fait: en dépit de quelques nuances dans le genre d'action, toutes les grandes nations européennes ont étendu leurs mains sur les parties encore primitives de la planète et de l'humanité, s'en sont attribuées la possession et se déclarent décidées à "mettre en valeur" la terre, et à "civiliser" les hommes, c'est-à-dire à mettre la terre en valeur monnayée, et à obliger les hommes à quitter leur civilisation propre, avancée ou rudimentaire, pour adopter la nôtre.

Une telle entrepise était grosse d'imprévu. Déjà bien des fractions de l'humanité ont disparu, n'ayant pas pu se plier assez vite au gré de nos impatiences. Et quant à la terre, ces mêmes impatiences caractéristiques de l'évolution de plus en plus rapide où nous engageons le monde et nous-mêmes, quant à la terre, dis-je, nous avons déjà eu le

temps de voir que la "mise en valeur" s'est résumée sur bien des points dans la destruction pure et simple de richesses latentes, qui, après leur transformation en monnaie, ont laissé la planète et l'humanité plus pauvres qu'auparavant: destruction des forêts, dessèchement de vastes régions, grande culture appauvrissante, peuples supprimés, guerres destinées à faire vivre artificiellement telles industries. Je me borne à ces quelques mots d'indication pour en arriver tout de suite à conclure que la conquête de la planète ne nous donne pas seulement des droits, dont nous serions libres d'user à notre guise, mais nous impose des devoirs envers le présent et l'avenir, et que la science doit intervenir, à titre d'indicatrice, pour nous dire de quel côté doit être orienté le gouvernail.

Mais cette science ne peut plus être fragmentaire ou isolée. La première nécessité du cultivateur qui élargit son domaine doit être de connaître ce domaine, et de le connaître tout entier.

La première nécessité pour l'humanité qui prend possession de la terre, c'est de connaître cette terre tout entière, et dans toutes les manifestations de sa vie.

Tout entière: d'abord dans son étendue, dans sa configuration, dans son relief. Après cela, dans sa vie physique, dans les mouvements de sa masse, de ses mers, de son atmosphère, dans l'échange de toutes ses parties—gazeuses, liquides, solides—qui fait que tout donne et que tout reçoit sur chaque point de la sphère humaine, et que tout est solidaire de tout. Enfin, dans les résultats passés ou dans les résultats futurs de cette vie planétaire, d'où dépend notre vie à tous et la vie de ceux qui viendront après nous.

Nous vivons en grande partie sur des illusions. Il nous semble que la terre est connue, parce que nous en dressons des cartes qui nous offrent l'inventaire apparent de la surface du monde. Mais si nous cherchons à nous rendre compte du degré de cette connaissance, nous sommes bien vite amenés à reconnaître que pour les neuf-dixièmes de la terre sa valeur scientifique est à peu près nulle. Nous savons bien que des objets de nature variable—plaines, montagnes, déserts, fleuves, mers—diversifient la surface du globe, et nous les dessinons sur nos cartes, mais avec quelle vague et faible approximation! A peine quelques pays de vieille civilisation ont-ils pu préciser leur propre forme superficielle; sortez de là, vous tombez dans l'à peu près. Et parmi ces pays plus avancés que les autres, combien en est-il où un industriel, un cultivateur désireux d'irriguer ses champs et d'en tripler les moissons, puisse faire emploi du travail cartographique antérieurement accompli? Bien peu; presque partout il faut mesurer et niveler à nouveau. Passez une frontière, et il vous arrivera la plupart du temps ce qui est arrivé à celui qui écrit ces lignes: la frontière pyrénéenne franchie, il a dû, pour connaître l'ordonnance véritable des monts

espagnols, oublier tout ce qui avait été fait, et reprendre le travail en partant de la terre même, pour le rattacher au lever de la France.

Des parties du monde entières sont encore étudiées et tracées à l'aventure, ou avec quelques points déterminés, épars, entre lesquels l'imagination du cartographe et la crédulité du lecteur ou de l'homme d'étude peuvent se donner libre carrière. Qu'on ne voie pas là une critique; chacun des fils mal tendus de ce réseau représente un effort, peut-être un effort héroïque; il n'en est pas moins vrai que le résultat est loin de concorder avec la réalité. Nous prenons une carte de Sibérie, la belle carte en huit feuilles publiée par le gouvernement russe. Pourrions-nous deviner que la plupart de ces fleuves aux méandres savamment ondulés n'ont jamais été vus ni tracés par une main consciente?

Nous sommes bien obligés, nous autres cartographes, d'utiliser ces documents si indigents lorsque nous n'en avons pas d'autres, mais quand ils se multiplient, se superposent, s'entre-croisent, les difficultés font souvent de même. Nous avons eu l'occasion au cours de la préparation d'atlas géographiques de reporter sur des projections préparées à l'avance les indications relevées par les intinéraires de voyageurs, les observations des astronomes, les sondages des navigateurs, les rivages parfois contradictoires des géomètres et des hydrographes chaque tracé nouveau venant se superposer aux tracés anciens, en ayant soin que l'origine de chacun puisse être aisément retrouvée, la valeur relative de chacun sérieusement établie. Eh bien, il suffit d'un coup d'œil jeté sur les enchevêtrements de lignes ainsi obtenues pour montrer, sans autre raisonnement, combien nous sommes loin du but, combien l'image du monde est visiblement loin de correspondre à ce monde lui-même, et combien il est malaisé parfois de trouver un fil conducteur pour choisir entre les versions différentes. Et c'est là l'état présent de la cartographie de la majeure partie de la surface terrestre.

Avons-nous le droit ou même la possibilité de nous approprier ce domaine, si nous ne sentons pas en même temps le devoir de le mieux connaître, pour le mieux utiliser, pour l'amener à l'harmonisation graduelle qui permettra à l'humanité de s'harmoniser elle-même?

La Russie ne pourra songer sérieusement à ressusciter l'Asie centrale; la France à peupler son Afrique du Nord ou à rattacher pacifiquement son Indo-Chine à la grande fourmillière chinoise; l'Angleterre à cultiver son empire immense comme il demande à l'être; l'Allemagne à développer ses colonies tropicales; l'Amérique du Sud à prendre dans le monde la place qui lui est due, que le jour où chacun de ces pays aura nettement défini la partie de la terre dont il s'est rendu maître et par conséquent responsable.

Mais si chacun travaille de son côté, sans unification possible avec le travail du voisin; si les méthodes, les mesures, les points de vue ne

peuvent s'harmoniser, si le travail de chacun reste sans utilité pour tous; si les réseaux de mesures fragmentaires ne peuvent se réunir en un réseau général; si l'étude du climat, des végétations ou des fleuves s'arrête à chaque frontière; si les résultats de la cartographie mathématique, physique, économique restent sans une mesure commune; si l'aide mutuelle ne facilite pas le travail général; si, en un mot, une union universelle ne permet pas à l'exploration terrestre de former un tout, jamais, disons-le bien haut, jamais la terre ne deviendra la site de l'humanité véritablement harmonisée et civilisée. Songeons, seulement pour prendre un exemple, à l'importance de la cartographie polaire, de la disposition des glaces flottantes dans l'économie générale des climats, dans la sécurité des cultures, par conséquent dans la vie matérielle de tout l'hémisphère nord. Songeons à ce tissu d'actions et de réactions réciproques qui fait que tout changement sur une partie du globe se repercute, obscurément mais sûrement, sur le globe entier; nous sentirons, sans avoir besoin d'insister davantage, la solidarité profonde qui oblige tous les hommes à étudier ensemble la planète qui les porte. Déjà cette nécessité a été sentie pour la précision des poids et mesures, pour la géologie, pour la géodésie. Elle ne le serait pas pour la cartographie, pour cette definition de la terre même, d'où découlent tant de prospérités ou tant de fléaux?

Aussi longtemps qu'on ignorait cette réaction intime et profonde de chaque phénomène terrestre sur tous les autres phénomènes de la planète et de l'humanité, cette solidarité universelle des climats, des courants, des effluves électriques, des phénomènes volcaniques, des reliefs, des végétations, de la faune, des groupes humains, alors que chacun pourrait se croire citoyen d'une société exclusive, sans lien avec les autres parties, l'étude fragmentaire de la terre était admissible. Aujourd'hui, si nous voulons répondre aux besoins du présent et surtout à la préparation de l'avenir, la réforme de la cartographie et son union sur toute la planète nous apparaissent comme ne pouvant plus être différées. On peut en dire ce que Ruskin disait d'une réforme morale qu'on déclarait impossible: "Je ne dis pas que ce soit possible, mais je dis que c'est indispensable."

FRANZ SCHRADER.

PARIS, *août 1904*.

PROPOSITION CONCERNING PUBLICATION OF RESOLUTIONS OF INTERNATIONAL GEOGRAPHICAL CONGRESSES

By JULES DE SCHOKALSKY

Having taken part in many geographical congresses, I am convinced that, first, the resolutions of the congresses, published by the committees, do not enjoy a sufficient publicity; and second, among the resolutions there were several which ought to be preserved for posterity.

The scientists present at these congresses certainly adopt these resolutions, but many young geographers often have not sufficient knowledge of them, because they are neither eager to read nor is it easy to obtain copies of reports of previous congresses.

To obviate these difficulties, I would propose that the committee of the present congress should undertake to collect all the resolutions of the previous cŏngresses which have a lasting value, and to publish them as an appendix to the resolutions of the present congress.

This plan must be adopted also by future congresses.

To give better publicity to all the resolutions of the international geographical congresses, the existing geographical societies of the whole world should be urgently requested to translate these resolutions and to publish them in their proceedings or journals, and in separate copies to disseminate them in their own country among geographers, and especially among the teachers of geography, as it is the only effective way to give the resolutions of the congresses the force of permanent laws, for the teachers will impress them upon their pupils.

PROPOSITION DE LA CRÉATION D'UNE ASSOCIATION CARTOGRAPHIQUE INTERNATIONALE

Faite par JULES DE SCHOKALSKY

La nécessité de la création d'une association internationale de cartographie a été déjà plaidée devant le Sixième Congrès des geógraphes, tenu à Londres en 1895, par M. le général A. de Tillo, mon maître et ami. Plus tard, cette question fut reprise par lui et présentée au Septième Congrès international de geógraphie à Berlin en 1899, lequel approuva cette idée et nomma une commission composée de MM. de Tillo, Schrader et le général de Steinmetz. Malheureusement le promoteur de cette idée, M. de Tillo, mourut au mois de décembre de la même année et n'eut pas le temps de pousser cette question suffisamment.

C'est au nom du défunt, dont j'ai eu l'honneur d'être appelé à continuer en Russie les travaux, que je présente ma proposition au congrès actuel. Madame Veuve de Tillo a bien voulu me transmettre les papiers de son mari, concernant la question, et j'y ai trouvé une collection d'avis de différents hommes de sciences et cartographes, tous, presque sans restriction, très favorables à l'idée d'inaugurer une pareille association. J'ai encore trouvé dans ces papiers une notice de M. le docteur Habenicht de Gotha sur les thèmes qu'on pourrait soumettre à résoudre[a] à cette institution, ainsi qu'un projet de statuts pour la future association.

A l'occasion d'une visite à presque toutes les grandes institutions cartographiques en Europe, gouvernementales et privées, faite par moi, en 1900, j'ai eu la possibilité de me convaincre que partout, auprès des chefs de ces établissements, l'idée de l'association trouvait un accueil des plus favorables.

Revenu en Russie, je fus activement occupé par des travaux relatifs à l'hypsométrie et aux cartes hypsométriques de l'Empire, commencés par M. de Tillo et actuellement continués sous ma direction. Ces travaux ayant un rapport étroit avec la cartographie en général, ainsi

[a] Ces idées, ou leurs analogues, ont été énoncées par M. Habenicht dans son article sur la carte au 1:1,000,000 de M. Penck, publié par le journal "Ausland," VI, 1892.

que maints autres, parmi lesquels je citerai une carte géographique de la Russie d'Europe au 1:2,000,000, présentée au congrès, dans l'Atlas de géographie publié sous ma direction, toute cette besogne cartographique m'a prouvé encore une fois combien il est difficile d'obtenir les données cartographiques nécessaires, même en étant au centre d'une accumulation de documents.

Sur mes instances, la Société impériale russe de géographie vient de créer une commission permanente de cartographie qui m'a fait l'honneur de me choisir comme président. Pour le moment cette commission s'occupe de la reconstruction de la carte de la Russie d'Europe à l'échelle de 1:1,680,000, ainsi que de la question de la transcription des noms qui ont à prendre place sur cette carte. Toutes les autorités cartographiques de la capitale russe prennent part à ces travaux et ont réussi à y intéresser tous les bureaux gouvernementaux se rapportant à la cartographie de l'Empire.

Si dans un Etàt séparé le travail cartographique pour un homme isolé devient déjà difficile, il en est de même, à plus forte raison, quand un pareil travail se rapporte à la cartographie de plusieurs Etats. Par conséquent il serait, à mon avis, tout à fait superflu de plaider ici encore une fois la nécessité de la création d'une association cartographique, proclamée d'urgence scientifique au congrès de Berlin; par conséquent, je passerai directement à ma proposition, basée sur celle de M. de Tillo.

L'association cartographique internationale a pour but de contribuer au développement de la cartographie qui est une branche essentielle de la géographie.

Pour atteindre ce but elle publiera un répertoire cartographique de toutes les contrées de la terre et s'efforcera de la tenir au courant; elle rapprochera les cartographes des divers pays et facilitera leurs rapports mutuels; elle s'occupera des questions techniques générales, ainsi que des signes conventionnels, transcriptions, et autres questions qui pourront naître; elle s'attachera à répandre et à tenir le monde géographique continuellement au courant des résolutions des congrès des sciences géographiques, ayant rapport à la cartographie; elle s'efforcera de provoquer l'exécution de travaux systématiques relatifs à la construction des cartes de grandes unités géographiques.

Pour atteindre le but annoncé, l'association pourrait être constituée de la façon suivante, et seront membres les institutions cartographiques gouvernementales de différentes espèces, les sociétés de géographie, académies des sciences, comités géologiques, instituts de cartographie privés et autres institutions scientifiques s'occupant de cartographie; les cartographes, géographes, géodésiens, astronomes, statisticiens admis par le conseil de l'association.

L'association comprendra une assemblée générale de membres se réunissant aux époques des Congrès internationaux de géographie; un

bureau central qui se réunira chaque deux années; d'un secrétariat permanent, chargé de publier les ouvrages entrepris par l'association, de tenir la correspondance, etc.

Pour couvrir les frais de l'association on pourrait recourir aux moyens suivants: Dotations annuelles des États participant à l'œuvre; contributions des instituts privés, et sociétés de géographie; cotisations des membres personnels.

Les États contribueraient à raison de leur population; par exemple, pour les États avec une population dépassant 20,000,000, 1,500 francs; de 5,000,000 à 20,000,000, 750 francs; moins de 5,000,000, 375 francs. Pour les sociétés de géographie et instituts privés, de 100 à 200 francs; pour les membres personnels, 25 francs, pouvant être rachetés par une somme de 250 francs.

La totalité pourra atteindre 25,000 francs par an. Je considère les détails indiqués par moi uniquement comme des matériaux pour les prochaines délibérations d'un comité, choisi et élu par le congrès, mais je propose que le congrès émette le vœu qu'aussitôt que le rapport de la susdite commission sera achevé, le bureau permanent du congrès ait le pouvoir d'entretenir les gouvernements, par voie diplomatique, de ce projet.

RESOLUTIONS ADOPTED BY THE EIGHTH INTERNATIONAL GEOGRAPHIC CONGRESS

MAPS OF SCALE OF 1:1,000,000

(1) The Eighth International Geographic Congress at Washington presents its thanks to the Service géographique de l'armée at Paris, to the Kartographische Abteilung der Königlich-Preussischen Landesaufnahme in Berlin, and to the intelligence division of the war office at London, for having commenced the publication of large maps on the scale of 1:1,000,000, which correspond in a general way to the maps of the world proposed by the congress at Berne, and it invites these offices to prepare an account of their maps, accompanied, if possible, by parts of them, for publication in the report of the Washington meeting.

(2) The congress proposes to the Government of the United States the execution of a general map of America on the scale of 1:1,000,000, similar to maps on the same scale of parts of Asia, China, and Africa now in preparation by the Service géographique de l'armée at Paris, by the Königlich-Preussischen Landesaufnahme in Berlin, and by the intelligence division of the war office at London; each sheet of the map being projected separately and being limited by parallels 4° apart and meridians 6° apart; the initial meridian being that of Greenwich, the initial parallel the equator; the standard of measures being the meter.

POLAR EXPLORATION

The Eighth International Geographic Congress, realizing that the only untouched fields for geographical discovery are the regions immediately surrounding the poles of the earth, desires to place on record its sense of the importance of forthwith completing the systematic exploration of the polar areas. It is very desirable that the experience gained by men of science and officers in the recent Antarctic expeditions should be turned to account by following up without delay the success they have obtained. The congress recognizes that the Arctic regions possess a more immediate interest for the people of North America, and expresses the confident hope that the expeditions now being prepared will be so supported as to secure early and complete success.

EARTHQUAKE INVESTIGATION

The International Seismological Association has accomplished the wishes of the seventh congress; therefore—

Resolved, That the Eighth International Geographic Congress sends its congratulations to the International Seismological Association, whose further work is waited for with great interest.

DEEP-SEA MAPS AND NOMENCLATURE OF THE EARTH'S BOTTOM

The Eighth International Geographic Congress expresses its thanks to His Serene Highness the Prince of Monaco for having executed the map of the ocean, the preparation of which was desired by the congress of Berlin, and expresses especially its agreement with the scale and projection chosen, with the adoption of the initial meridian of Greenwich, with the adoption of the meter for indication of the depths, and with the system of international submarine terminology used.

RULES FOR GEOGRAPHIC NAMES

Local names are, as far as possible, to be preserved not only in those regions where already established, but also in wild regions. They should on this account be determined with all the accuracy possible.

Where local names do not exist or can not be discovered, the names applied by the first discoverer should be used until further investigation has been made. The arbitrary altering of historical, long-existing names, well known not only in common use, but also in science, is to be regarded as extremely unadvisable, and every means should be employed to resist such alterations. Inappropriate and fantastic names are to be replaced, as far as possible, by local and more appropriate names.

The above rules are not to be rigorously construed, yet they should be followed to a greater extent than heretofore by travelers and in scientific works. Their publication in periodicals as the opinion of the congress will probably prove of great weight. Although in recent years many official systems of determining geographic names have been enunciated, yet we have evidence of the very slight influence which the wishes of international geographic congresses exert upon the decisions of the official authorities.

INTRODUCTION OF THE FRACTIONAL SCALES OF MAPS

The Seventh International Geographic Congress expressed the urgent wish that upon all charts, including those published by countries still employing the English or Russian systems of measurement, the scale of reduction be expressed in the usual fractional form, $1:x$, along with the scale of geographic coordinance, and that the fractional form be added to all lists of charts covering land and sea, and requested the

executive committee of the congress to bring this decision to the attention of all governments, geographical societies, and establishments engaged in the publication of charts.

The advantage to be derived from the support of this resolution, which has its origin with the editor of Petermans Mittheilungen, and from the extensive dissemination of the resolution, is at once evident. In English publications a custom has arisen of adding a statement of the ratio $1:x$ to the scale usually employed, x miles to 1 inch. In America the custom has arisen of going even a step beyond this, namely, the addition of the ratio of reduction has led to the direct application of the decimal system in the units of measure adopted upon the chart.

THE DECIMAL SYSTEM

The Seventh International Geographic Congress expressed itself in favor of a uniform system of measurements in all geographical researches and discussions, and it recommended for this purpose the employment of the metric system, and also the employment of the centigrade thermometric scale.

It is, moreover, highly desirable that there should always be added to measurements stated in the Fahrenheit and the Reaumur scales their equivalent upon the scale of Celsius. Similar to this is the question of the metric system, the use of which reaches even more deeply than the former into the well-established customs of daily life and has proved not without value in promoting international uniformity and simplicity. Although the metric system of weights and measures has made slow progress, and this alone through the portals of scientific work, its application to geophysics and geography has already been fairly begun. In England a special organization, entitled the Decimal Association, has taken charge of the matter. The Commonwealth of Australia has intrusted the subject to a commission.

COLLECTION OF RECORDS OF DRIFT ICE

The systematic collection of records of drift ice is progressing satisfactorily in the Danish Meteorological Institute and the cooperating offices.

STATISTICS OF POPULATION IN COUNTRIES WITHOUT CENSUS

Resolved, That a committee of five be appointed by the president to confer with a committee of the International Statistical Institute on methods of obtaining the population in countries taking no census.

STANDARD TIME

Resolved, In view of the fact that a large majority of the nations of the world have already adopted systems of standard time based upon

the meridian of Greenwich as prime meridian, that this congress is in favor of the universal adoption of the meridian of Greenwich as the basis of all systems of standard time.

PUBLICATION OF PHOTOGRAPHS

The lantern slides shown by Mr. Siebers and the photographs exhibited by Mr. Willis at this congress suggest that it is desirable that these and other photographs of geological features be published, with short explanatory notes, so that they may form a collection of representations of physical features of different parts of the world.

CARTOGRAPHICAL ASSOCIATION

The congress refers the proposition of Mr. Schokalsky and the paper of Mr. Schrader to the committee appointed at the congress of Berlin to consider the cartographical association. This committee is requested to report on the necessity of a cartographical association to the next congress. In the meantime it might interest geographical societies in the plan and in the necessity of dealing with maps in geographical journals in a more detailed way than usual, and urge that a general use of maps should be popularized and extended by instruction in schools, and that the commerce in maps should be better organized.

The death of General Tillo and the withdrawal of General Steinmetz having reduced the committee to a single member (Mr. Schrader), the congress appoints the following gentlemen to serve on the committee: Mr. Henry Gannett, Washington, chairman; Mr. Jules de Schokalsky, St. Petersburg (successor to Mr. Steinmetz); Mr. Franz Schrader, Paris; Professor Oberhummer, Vienna; Mr. Bartholomew, Edinburgh.

PLACE OF HOLDING THE NINTH INTERNATIONAL GEOGRAPHIC CONGRESS

Resolved, That the congress accepts with pleasure the courteous and hearty invitation of the Swiss Government and of the Geographic Society of Geneva to hold the Ninth International Geographic Congress in the city of Geneva in 1908, and expresses its appreciation of the invitation extended through the representative of the Swiss Government and of the society, Prof. Arthur de Claparède.

Resolved, That the hearty thanks of the congress are hereby conveyed to the Hungarian Government and to the Geographical Society of Hungary for the courteous invitation to hold the Ninth International Geographic Congress in the city of Budapest. While deeply sensible of the honor of this invitation, the congress has decided to hold its next session in Geneva, Switzerland.

PRESENTATION TO COMMANDER PEARY OF THE GOLD MEDAL OF THE PARIS GEOGRAPHICAL SOCIETY

At the dinner on September 14, in New York, Prof. Henri Cordier, president of the Paris Geographical Society, in a felicitous speech, presented the society's gold medal to Commander R. E. Peary, in recognition of his many and valuable contributions to the world's knowledge of Arctic regions. It was acknowledged by Commander Peary in a speech in which he briefly outlined his plans for his coming expedition.

PRESENTATION OF THE MONTHERET MEDAL

M. Henri Cordier, president of the Paris Geographical Society, presented the society's Alphonse de Montheret prize, a silver medal, to Mr. Frank W. Stokes in recognition of his artistic work in both Arctic and Antarctic. In the absence of Mr. Stokes the medal was received and acknowledged by Chairman Bryant.

PAPERS, ABSTRACTS, AND DISCUSSIONS

TITLES OF PAPERS NOT OBTAINED

There were 220 titles of papers offered to the congress. Of these, 116 were read before the congress, the remainder being read by title only, in the absence of the authors. Of the papers offered, 119 have been obtained, in full or in abstract, and are published in the succeeding pages.

The following papers, which were read before the congress, were not, for one reason or another, obtained for publication:

Glacial erosion in the finger lake region of New York. M. R. Campbell, Washington, D. C.

Physiographic aspects of China. Bailey Willis, Washington, D. C.

The submarine canyon of the Hudson River. J. W. Spencer, Washington, D. C.

A reported island in the Pacific Ocean between Hawaii and Panama. James D. Hague, New York, N. Y.

Neuere Untersuchungen über das Adriatische Meer. Prof. Albrecht Penck, Vienna, Austria.

The last uplift of the Alps. Prof. Albrecht Penck, Vienna, Austria.

Chatter-marks, or crescentic subglacial fractures. G. K. Gilbert, Washington, D. C.

The Antarctic glaciers. Henryk Arctowski, Brussels, Belgium.

Glaciation in China. Bailey Willis, Washington, D. C.

Pigmy tribes of Africa and their distribution. S. P. Verner.

The Ainu, aborigines of Japan. Prof. Frederick Starr, Chicago, Ill.

Race types and peoples assembled at the Louisiana Purchase Exposition. W J McGee, Washington, D. C.

Correlation between ethnic types and environment. W J McGee, Washington, D. C.

Anfänge der Völkerkunde in der Bildenden Kunst. Dr. Eugen Oberhummer, Vienna, Austria.

Madagascar before the French occupation and to-day. Prof. G. Grandidier, Paris, France.

Geographic elements. Dr. H. R. Mill, London, England.

The Antarctic. Dr. H. R. Mill, London, England.

Geographical development of the internal commerce of the United States. Dr. J. F. Crowell, Washington, D. C.

Physical geography of Chicago. Prof. R. D. Salisbury.

Economic geography of Chicago. J. P. Goode.

Economic geography of Canada. Dr. James White, Ottawa, Canada.

North America as known in 1804 and 1904. Mr. Gilbert H. Grosvenor, Washington, D. C.

Typical early maps of the New World. Prof. E. L. Stevenson, New Brunswick, N. J.

Visual instruction in America. Prof. A. S. Bickmore, New York, N. Y.

PHYSIOGRAPHY OF THE ARCHEAN AREAS OF CANADA

By Prof. A. W. G. WILSON, McGill University, Montreal, Canada

INTRODUCTION

The present paper offers a brief general description of the more salient physiographic features of the Archean areas of Canada. The paper is based upon the reports of the many explorers who have traversed this area in its different parts. The writer's own field work in several parts of the area has served as a basis of interpretation where his method of description departs from that of the authorities from whose work this summary was prepared.

No attempt is made to discuss the imperfectly known geology of the very large area here under consideration. The purpose of the paper is rather to draw attention to the remarkable unity of the physiographic features of the region in its whole extent and to present a brief description of their most marked characteristics.

AREA AND EXTENT

The Archean areas of Canada, the Canadian Shield of Suess, extend around Hudson Bay in a U form, reaching from Hudson Strait on the northeast, southward through Labrador, Quebec, northern Ontario, and then northwestward through the district of Keewatin and part of the district of Mackenzie to Coronation Gulf, in the extreme northwest. South of the international boundary lie two small areas that form, both geologically and physiographically, portions of this great unit. They are the Archean areas of the Adirondacks in eastern New York State and the Archean areas of Michigan and Wisconsin. The region extends through about 58 degrees of longitude and about 23 degrees of latitude, covering over 2,000,000 square miles.

EXPLORATION AND SURVEYS

More than ten centuries have elapsed since the first daring Norse mariner landed on the eastern shores of North America. Since that time all the early French explorers and many others have traveled along the eastern margin of the Archean areas of Canada, and a few have made short excursions into the interior. The bold and forbidding coast along the St. Lawrence River, in contrast with the more easily

accessible, more inviting, and equally unknown areas to the west and south, for a long time diverted the attention of explorers from this field. At a somewhat later period the continued active exploration prompted by the desire to find a short route to China and India resulted in the discovery of Hudson Bay. This great inland sea gave these early explorers access to the very heart of the continent. Pressing ever westward, still searching for the much-desired Northwest Passage, several exploration parties attempted land journeys across the extreme northwest portion of these Archean areas. The records of these explorations still supply the only available information regarding certain parts of this district.

Not long after the discovery of the rich and fertile districts in the basin of the St. Lawrence River, and of the immense bay to the north, the great profits to be made in the trade of furs and skins led incidentally to the rough exploration of many well-defined routes across the land areas intervening between the great bay and the St. Lawrence River. The interests of the fur trade also caused the establishment of trading posts on the shores of the great bay and inland. Some of these, established over two centuries ago, are still centers of an active trade.

Contemporaneously with the exploitation of the country for the purpose of profit we find that from the French settlements on the St. Lawrence the intrepid Jesuit missionaries penetrated far into the interior of the country to visit the wandering Indian tribes. The imperfect records of these long, always arduous, and often dangerous journeys have been most important contributions to our early knowledge of many of the more important routes of travel and exploration.

The period of active geographic and geologic investigation really began about sixty years ago with Sir William Logan's historic work on the geology of the Archean districts north of the Ottawa River. Since that time more or less systematic geographic and geologic explorations have been carried on, chiefly by the Geological Survey of Canada, but in part by the Topographic Survey's branch of the Department of the Interior at Ottawa. At present we have at least a general knowledge of the main geographic features of the whole area, though much still remains to be done.

The most accurate and detailed knowledge of these areas now available depends largely upon the very recent labors of the present survey staff. Our knowledge of the interior of the Labrador Peninsula and of the adjacent parts of the Province of Quebec depends chiefly upon the work of Mr. A. P. Low during the seasons 1886–1898.[a] The more important explorations of the districts south and southwest of James Bay have been made by Dr. Robert Bell and Dr. A. E. Barlow, but some work has been done by other members of the survey staff, and some by independent observers. Since the adventurous

[a] See Reports of the Geological Survey Canada, Vols. I-VIII.

wanderings of Hearne (1769–1772) over portions of the extreme northwest part of the area northwest of Great Slave Lake, little had been done in this region until the work of the Tyrrell brothers began. In 1893 J. B. Tyrrell and J. W. Tyrrell made a journey across the barren grounds from Great Slave Lake to Chesterfield Inlet and thence south to York Factory. In 1894 Mr. J. B. Tyrrell again crossed this area, but farther to the south. In 1900 Mr. J. W. Tyrrell made a traverse for the department of the interior, traveling for the second time from Great Slave Lake to Chesterfield Inlet, but by a different route from that taken in the earlier trip.

Numerous other shorter explorations have been made by these and other members of the Canadian Geological Survey staff, and by a few private individuals. In the reports by Mr. A. P. Low, Mr. J. B. Tyrrell, and Mr. J. W. Tyrrell, nearly complete bibliographies will be found. It thus does not seem necessary to repeat them here. [a]

RELATION OF THE ARCHEAN AREAS TO ADJACENT AREAS

The Archean areas of Canada form, as it were, the breastbone of the North American continent. In its general features North America presents a most striking example of the typical development of the physiographic forms characteristic of a belted ancient coastal plain centered around an oldland area.

THE CANADIAN OLDLAND

The Archean areas of Canada mark the site of the region from which the materials of the later sedimentary deposits were derived. Attention has already been called to the present geographic extent and general U-form of this oldland area. Its width varies from nearly 1,000 miles in Labrador to about 200 miles in the country southwest of James Bay.

THE ANCIENT BELTED COASTAL PLAIN

Bordering the oldland on its convex side and extending from the island of Anticosti in the Gulf of the St. Lawrence westward and northward as far as the Arctic Circle, and probably beyond, we have a series of land forms presenting on the grandest scale the general features of an ancient belted coastal plain, in its present aspect much modified, it is true, from normal form—a modification probably due to the operation of relatively recent processes, differential uplift, and

[a] Low, A. P., Report on explorations in the Labrador Peninsula along the East Main, Koksoak, Hamilton, Manicuagan, and portions of other rivers in 1892-1895: Canadian Geol. Survey, Vol. VIII, new series, Report L.

Tyrrell, J. B., Report on the Doobaunt, Kazan, and Ferguson rivers and the northwest coast of Hudson Bay, and on two overland routes from Hudson Bay to Lake Winnipeg: Canadian Geol. Survey, Vol. IX, 1897, new series, Report F.

Tyrrell, J. W., [Report of an] exploratory survey between Great Slave Lake and Hudson Bay, districts of Mackenzie and Keewatin: Canada, Dept. of the Interior, Report for 1901, Part III, 1901, pp. 98–155.


Mackenzie

glacial action. The belted coastal plain features are best preserved in the region of the Great Lakes.

The most prominent topographic feature of this coastal plain is the Niagara cuesta, which can be traced with varying expression from near the city of Rochester on the south shore or Lake Ontario, westward as far as the State of Wisconsin. Beyond this it disappears for a time beneath the drift, but reappears to the west of Lake Winnipeg. Lakes Erie, Huron, Michigan, Manitoba, and Winnipegosis are situated upon the outer lowland. Lake Ontario, Georgian Bay, Green Bay, and Lake Winnipeg lie upon the inner lowland in front of the cuesta. Lake Superior lies in a depression outside of both lowland and cuesta. The portion of the ancient coastal plain in the vicinity of the Great Lakes presents, in its general aspect and in its present attitude, the normal features of such a plain, with numerous drainage modifications due largely to differential uplift and glacial ice action. The portion of the plain which lies west of the oldland area is at present in such an attitude that practically all the streams flow against the dip of the rocks—a direction opposite to that normally found on a belted coastal plain—a modification in this case apparently due to the uplift of the Cordilleran system on the west.

On the southeast side of the oldland the valley of the St. Lawrence lies on a lowland cut on Paleozoic sediments. It shows, at the extreme west in the valley of the Ottawa River, and at the east in the Mingan Islands and the island of Anticosti, typical cuestas with inner and outer lowlands. In the central parts, in the vicinity of the city of Montreal, the relation of the plain to the oldland areas, which stand boldly above it on either side, suggests that here the Paleozoic sediments may have been deposited in a pre-Paleozoic depression of the graben type. The well-known Monteregian Hills, the stubs of post-Devonian volcanoes, form prominent buttes rising to a considerable elevation above the level of the St. Lawrence plain. During the period of Appalachian folding, and possibly even before it, the modifications of the geological features to the southeast of the oldland between Newfoundland and southwestern Quebec materially controlled and modified the development of the topographic features of this area.

On the Hudson Bay side of the oldland are traces of an old belted coastal plain, convex southward, but most of its features are buried beneath the deposits that form the modern Hudson Bay coastal plain.

CHARACTERISTICS OF THE TOPOGRAPHY

CHARACTER OF THE SKY LINE

The most widespread and dominant feature of the topography, a feature to be noted almost everywhere throughout the whole area, is the remarkably even character of the sky line. When it is remembered that everywhere the character of the rocks—their structure

and their composition—indicates that the region has been one of intense metamorphism and probably of mountain building, and that this remarkably even plain now truncates all rocks alike, irrespective of their structures or attitude, this feature is the more striking. With few exceptions, to be noted elsewhere, almost everywhere in the interior it is found that from any slight elevation which lifts the observer above the tree line, the bounding horizon is very even and almost circular. The many traverses which have been made across the different parts of the area show, particularly for the western portion of the region between the Great Lakes and the Arctic Ocean, that for many miles the greatest elevation is often not over 50 or 75 feet higher than the adjacent lowest depression, and as a rule the actual surface may be described as gently undulating. Occasionally the measure of relief may equal 100 feet, but particularly in the western part of the region elevations of this amount are prominent landmarks, visible for many miles, and from a distance are frequently seen to stand above the even sky line of the adjacent regions, so that they may more properly be classed as monadnocks. In the country to the south of James Bay the measure of relief is somewhat greater, but the even sky line, occasionally intercepted by residuals, is still the dominant topographic feature. In the Labrador portion of the area, for long distances in its central parts, the surface is practically the same as on the western half. Toward the margins it is more rugged or uneven, while toward the extreme northeast, close to the Atlantic coast, a narrow range of mountains rises prominently above the general plain level. Because of the remarkably even character of the sky line—due to the character of the surface, which truncates all structures alike—and for other reasons given in a subsequent paragraph, this truncating surface will in the subsequent discussion be referred to as a peneplain surface—that of the Laurentian peneplain.

The remarkably even character of the sky line, together with the universal distribution of many large and small lakes at levels little below that of the even sky line, justifies the assumption that differences of elevation between different water bodies in the depressions upon the surface of the plain represent closely the differences in elevation between portions of the peneplain adjacent to each of these water bodies respectively. On this basis it will be found that the average gradient varies in different parts from 1 foot to about 4 feet per mile. For example, between Selwyn Lake (1,340 feet) and Doobaunt Lake (500 feet), along the line of the Doobaunt River, west of Hudson Bay, the average gradient is 2.8 feet per mile for approximately 300 miles. A section extending eastward from Cree Lake (1,530 feet) to the junction of the Churchill and Little Churchill rivers shows an average gradient of 1.8 feet per mile for 450 miles. A study of the profiles of the Canadian Pacific Railway between Montreal and Winnipeg, where

the line runs over the upland, shows, between Buda (1,472 feet) and Brulé (1,355 feet) a fall of 117 feet in a distance of 146 miles; between Cartier (1,398 feet) and Lac Poulin (1,504 feet) the gradient is 106 feet in a distance of 129 miles. In central Labrador a section between Lake Nichikun (1,760 feet) and Lake Kaniapiskau (1,850 feet), and thence to Lobstick Lake (1,630 feet), above the Grand Falls on the Hamilton River, shows an ascending gradient of 90 feet in the first 100 miles, and then a descent of 220 feet in 200 miles, or a mean gradient of approximately a foot per mile. In a direction along the divide (1,550 feet) from the southeast of Lake Mistassinni to Lake Kaniapiskau (1,850 feet), the rising gradient is almost exactly 1 foot per mile.

By way of comparison, from the profiles of the Canadian Pacific Railway between Winnipeg (757 feet) and Calgary (3,428 feet), in the foothills of the Rockies, the gradient is found to be 3.18 feet per mile. Between Edmonton (2,407 feet) and East Selkirk (744 feet), along the old location line via the Yellowhead Pass, the gradient is 2.1 feet per mile. In each of the above cases, if shorter sections are taken on each of the three prairie steppes, it will be found that for each steppe the gradient across the plains is much less than the figures here given.[a]

The comparison of the two gradients across the great plains with the gradients upon the peneplain surface, taken in conjunction with the character of the sky lines in the two areas, shows the appropriateness of the term "peneplain" as a term to describe the principal geographic features of this topographic unit.

CHARACTERISTIC RELIEF

ELEVATIONS

When the character of the surface is considered more in detail it is found that, except in some very small areas and in places where the planation surface is buried beneath the much younger glacial and alluvial deposits, nowhere is the present surface quite flat. Rather is it covered with low, rounded domes and ridges, which are roughly parallel to one another and whose longer axes conform in general to the strike of the rocks. The size of these domes varies greatly in the different parts and seems to be a function of the character of the rock, its attitude and structure. In ground plan they are generally elliptical. In relief they often rise from a few feet to perhaps 200 feet above the adjacent depression. Occasionally in some localities the relief may even exceed this amount. The character of the topography is thus dependent on the ratio which exists between the measure of the relief and the measures of the horizontal axes of the more or less ellipsoidal domes. Where this is great, as in central Labrador

[a] In the profiles taken along the lines of river valleys it is to be noted that the distances are estimated in straight lines, not along stream courses. It will be found that the average gradient of the stream course is much less.

and in Keewatin, the topography may usually be described as gently undulating or rolling. Where this becomes less it approaches that which would be termed hummocky. In general the topography of the entire area is rolling, but there are areas of considerable extent where it is decidedly hummocky.

MONADNOCKS

Almost everywhere throughout the region are found more or less isolated domes and ridges whose surface contours, when they are viewed from a distance, are seen to make sharp, well-defined angles with the general surface of the plain as indicated by the even sky line. The elevation and development of these residuals seems to depend largely on the character of the material of which they are composed and upon that of the material by which they are surrounded. The most prominent residuals of this type which have been reported within the limits of the area are those mentioned by Barlow and McOuat as occurring in the region west and north of Lake Temiscaming, where hard quartzite ridges stand in places as much as 700 feet above the plain surface. The Baraboo ridge in Wisconsin, an outlying monadnock ridge rising through the Paleozoic sediments, is comparable with these. Another excellent example, and one of considerable historic interest in connection with Logan's early work on the geology of the Archean, is Trembling Mountain, lying north of the Ottawa River and northwest of the city of Montreal. The mountain is a domed monadnock rising over 800 feet above the general level of the adjacent plateau, here about 2,380 feet above sea level.

There are two widely separated areas of considerable extent, the greater portion of which stand well above the general level of the peneplain surface. One of these is the Adirondack region in eastern New York. The relation of this area to the peneplain of the central Archean areas of Canada is at present undetermined. The other area lies along the northeast coast of Labrador. Here a range of mountains with peaks rising as much as 5,000 feet above sea level, extends along the coast for several hundred miles, and has an approximate breadth of about 50 miles. These mountains rise sharply from the interior Labrador plateau, reach above the limits of ice action of the Glacial period, and present a type of topography quite distinct from that characteristic of the whole of the Archean area lying to the southwest. Beyond the fact that they rise distinctly above the peneplain their relation to it is undetermined and uncertain. They may be the product of orogenic processes acting sometime subsequent to the peneplanation period, and after their uplift they may have been redissected so that all traces of the peneplain surface which may have traversed them have disappeared. Little is known concerning their origin, structure, and history. When this is worked out their relation to the peneplain areas to the south may possibly be determined.

TOPOGRAPHIC DEPRESSIONS

The counterparts of the elevations are of course the depressions. The measure of the one must necessarily be that of the other. A comparative study of the various depressions suggests a provisional recognition of three distinct types:

First. Broad, shallow depressions, which lie between the more or less hummocky or undulating ridges that occur upon the upland itself, and which are probably in the main of contemporaneous origin with the surface of the peneplain, and are presumably due to local differential erosion.

Second. Broad, open depressions, which are generally in part occupied by sediments provisionally classed as Cambrian. These depressions lie below the plain level, and may be due to either of two causes—(1) downfaulting of a graben block, or (2) river erosion.

Third. Deep, narrow channels, in places gorges, with steep, often inaccessible sides, distinctly incised beneath the level of the adjacent upland.

1. *The upland depressions.*—In considering the drainage features of the whole peneplain it is found that the drainage basins of the larger river systems indicate approximately the existence of large, amphitheater-like basins, each draining toward its own median axis. When the topography is considered more in detail it is found that each of these drainage basins is divided into a number of minor basins, each with its local drainage system more or less imperfectly developed. For the most part the minor depressions of these local basins are occupied by small lakes, usually with rock basins, the water in each of these local basins spilling over the lowest edge to the next lowest one below. The depth of these minor depressions on the peneplain surface below the level of the water in the basin rarely exceeds and is usually much less than the elevation of the adjacent ridges above the same datum level. In parts of the area the surface of the peneplain submerged approximates as much as 25 per cent of the whole.

The water filling of a number of the adjacent minor depressions may reach an elevation sufficiently great to unite many of them into a large lake or series of lakes dotted with islands, where the ridges between the adjacent minor basins project above the surface of the water. These island-dotted lakes form a characteristic feature of most of the uplands. One of the finest easily accessible examples of this type of lake is Temagami in New Ontario. The eastern shore of Georgian Bay, with its 30,000 islands, marks the place where a small section of the peneplain passes beneath the water level of Lake Huron.

Upland lakes in basins of the type here described, when occurring in the vicinity of divides, often have outlets in two or more directions. At the present time Temagami has two outlets, a portion of its waters eventually reaching the Ottawa River and another portion flowing to

Lake Nipissing and Georgian Bay. A rise of a few feet would give the lake four outlets. Reindeer Lake, in eastern Athabasca, is a large lake on a divide between the Churchill and Mackenzie river basins. A part of its waters flows southward and then eastward via the Churchill River to Hudson Bay, and a part flows via the Cochrane River and Wollaston Lake to Lake Athabasca, and eventually reaches the Arctic Ocean. Similar lakes, both large and small, with outlets in two directions, are frequently found anywhere upon the peneplain.

2. *Depressions containing sedimentary deposits.*—The occurrence of valleys partly occupied by sediments which have been called Cambrian has been reported by Low in Labrador and by Tyrrell in northern Keewatin and eastern Mackenzie. Outlying areas of Paleozoic sediments are found in the basins occupied in part by Lakes Nipissing, Temiscaming, St. John, and Mistassinni.

Low, in describing certain of these valleys in Labrador, mentions that the streams are often from 500 to 1,000 feet below the level of the plateau. The heads of the valleys are from 100 to 300 miles from their mouths, and at the upper ends the rivers descend from the level of the interior in a succession of heavy falls through narrow gorges, where processes of erosion are at present slowly extending and deepening the valleys. The valley of the Hamilton River he describes as from 700 to 1,200 feet below the level of the plateau. Some of these ancient valleys have been more or less filled with glacial débris, and the modern streams for part or all of their lengths have taken new courses.

Some of the depressions in which these sediments lie seem to be ancient broadly open valleys and are considered by those who have had the opportunity of studying them in the field as of pre-Cambrian age. In the case of Chesterfield Inlet, Tyrrell notes that the sides are steep and in places cliffed. Back's description of the country immediately north of the east end of Great Slave Lake would lead one to infer that the sides of this presedimentary valley were also well defined. In the Labrador region the margins of the depressions in which the sediments occur are well defined. This is strikingly true of the lower and partly submerged valley of the Hamilton River. The Mistassinni depression is bounded by a well-marked rock scarp on the southeast and a less definite but still distinct margin on the northwest. The Lake St. John basin seems to be of a distinctly graben type; its margin is well defined, often cliffed or scarped, and all the streams tributary to the lake spill over the edge of the basin of the lake proper from the adjacent upland, each in a series of waterfalls and cascades, often visible many miles away from the open lake.

The sediments in the Lake Temiscaming and Lake Nipissing basins are in valleys lying below the level of the plain. The sediments in the vicinity of Lake Nipigon rest directly upon the plain and rise above its surface level.

In the greater number of cases it seems that the valleys have well-defined margins and it is probable that the majority of those in the localities above referred to antedate the peneplanation epoch, and that the sediments lying within them have been partly reexcavated since then. The depressions occupied by Lake Nipissing and Lake Temiscaming, and possibly those occupied by Lake St. John and Lake Mistassinni, may antedate the peneplanation. In the majority of cases there is not at present sufficient available evidence to warrant an extended discussion of this very interesting problem.

Barlow notes that the Lake Temiscaming depression and others in that vicinity bear no significant relation to the direction of the movement of the glacial ice; in fact, they lie at various angles, up to as much as 90° to the general direction of movement of the ice sheet. He also notes that many of them cut across hard and soft rocks alike, and bear no relation to the strike of the structure of the rocks.

3. Gorge and canyon valleys.—Narrow, steep-sided valleys and gorges, some many miles in length, some extending only for a short distance, are of frequent occurrence in various parts of the peneplain. Many of them are found in the Labrador area, through which the drainage of the interior upland passes down to Hudson Bay, to the St. Lawrence River, or to the Atlantic Ocean. One of the most interesting of these is the gorge of the Hamilton River, described by Low as occurring above the more open, partly submerged valley of the second type here described, in which certain sediments lie and which forms the lower part of the valley of the same river. The numerous rivers which enter the gulf and river of St. Lawrence from the northwest pass through deep, steepsided valleys, often canyons with unscalable walls, at times cut to a depth of over 1,000 feet below the level of the peneplain.

The depression farther west, occupied by the lower part of Lake Temiscaming and the Ottawa River as far down as Mattawa, seems to belong to this category. In the immediate vicinity of Lake Temiscaming there are a number of other gorges and valleys, the former much narrower and smaller than the Temiscaming depression, cut beneath the surface of the plain, at times even across weak and hard rocks alike, independent of the structure.

The edge of the plain along the north shore of Lake Huron and Lake Superior stands at a very considerable elevation above these water bodies, and in this locality there are many southward-flowing streams occupying steep-sided valleys incised well beneath the peneplain. In the northwest part of the area similar gorge-like valleys occur, but they are generally smaller and shorter and are less prominent features. So far as known, valleys of this class are never found to be occupied by the supposedly pre-Cambrian sediments, and they always have a well-defined "shoulder" where the gradient curves of the valley

sides intersect the flatter curves of the upland surface, and their general relations suggest that their origin dates from a time subsequent to the period of planation.

DRAINAGE FEATURES

Lakes.—Correlative with the generally even character of the surface of the country and with the occurrence of the rolling or hummocky topography we find certain characteristic drainage features. Reference has already been made to the general amphitheater-like arrangement of all the principal drainage lines. Attention has also been drawn to the fact, characteristic of the whole area, that the majority of the minor depressions form innumerable and characteristic rock basins in which the water gathers to form large and small island-dotted lakes.

In addition to the lakes and associated drainage features of this class we occasionally find several other types. One of the commonest of these is the longitudinal lakes occupying old valleys that are more or less blocked by débris or by means of other geologic causes, in some cases, presumably, by differential uplift. There are other examples of long, narrow lakes whose depressions are ascribed to the erosion of softer dikes. Over fifty years ago Agassiz drew attention to the fact that many of the bays and points on the shores of Lake Superior owed their origin to the erosion of soft dike rocks. More recently Bell has attributed the origin of certain channels along the Lake Huron shore and the longitudinal basins of certain inland lakes north of Lakes Huron and Superior to a similar process.

One of the most interesting lakes of the longitudinal type is Temiscaming, and the "Deep River" of the Ottawa adjacent to it. Dr. Barlow describes the valley as a very steep rocky gorge, fringed on either side by lofty hills or perpendicular cliffs which rise abruptly to a height of from 400 to 600 feet above the surface of the water. The average of a large number of soundings indicates that the lake has a mean depth of over 400 feet. Hence the bottom of the lake lies about 1,000 feet below the level of the surrounding country. The bottom of the lake, wherever examined, was found to consist in the deeper portions of a very fine gray unctous clay or silt, so that the depth may have been much greater before the accumulation of this material. Whether the depression is of the graben type, somewhat similar to Lake Tanganyika in Central Africa, or whether it is to be ascribed to the blocking or warping of a pre-Glacial gorge it is at present impossible to say.

Lake St. John is another example of a lake occupying a depression which seems to be of the graben type. On the other hand, Lake Nipigon, a lake of considerable area and depth, lies for the most part directly upon the surface of the peneplain and seems to owe its origin to the formation and subsequent blocking of an inner lowland between the old land area and some of the relatively recent sediments which

rest upon the peneplain surface and have a well-defined cuesta front facing toward the old land. This lake is, however, a special case and an exception to the general types of lakes found within the Archean areas. Its occurrence is due to the accident of the preservation of a considerable mass of sediments upon the surface of the peneplain well within the present boundaries of the area.

ORIGIN OF THE PRESENT TOPOGRAPHIC FEATURES

The relations of the Paleozoic sediments on both borders of the Archean areas to the peneplain surface suggest several interesting problems. Just along the margin of the belted coastal plain the portion of the Archean surface that has been denuded of its once thick cover of Paleozoic sediments shows essentially the same features that are found in the central areas, which must have been uncovered long ages before. The most noticeable difference is a slight increase in the average slope of the plain where it passes beneath the covering of sediments. In the interior, as shown in a previous paragraph, the slope of the surface is roughly about 4 feet per mile, while around the margin in places this gradient reaches as much as 20 feet per mile toward the Paleozoic sediments. At present it is not possible to say whether there are two or more plains meeting at a low angle or whether the difference in gradient is due to a slight warping of the surface.

The origin of the plain and the origin of the present topographic features of the region, which are uniform over a vast area, are interesting problems, but the data at present available for their solution are so meager that at best they can be but briefly discussed.

Age of the uplift of the Canadian shield.—The rock structures and rock textures throughout the region indicate that it must once have been an area of intense mountain building, possibly by a series of uplifts which formed a series of parallel mountain ranges. At present these ranges have almost completely disappeared; only the roots or bases remain. The earlier studies of the Cambrian by Walcott and the more recent investigations of the later Paleozoic faunas of North America by Ulrich and Schuchert have led these authors to the conclusion that "at the beginning of Ordovician time the greater portion of the Canadian shield was above sea level, and that since early Cambrian time it has never been wholly submerged." The work of Laflamme, Adams, Lawson, and others has shown that along the southern margin of the peneplain, from Lake St. John to Lake Winnipeg, where the plain passes beneath the Ordovician sediments to the south, it possesses the same hummocky character and often the nearly fresh surface that it does in districts remote from the margin. Between the farthest outliers (exclusive of the outlying areas which may owe their preservation to the downthrow of fault blocks) there is a belt of uncovered presedimentary surface, which shows all the features everywhere characteris-

tic of the modified peneplain. Hence not only must the portion of the plain adjacent to the areas now overlain by Paleozoic sediments be of pre-Ordovician date, but the dissection which it has undergone must also be pre-Ordovician. The dissection is regarded as of different date from the planation because the gradient curves of the valley sides are not accordant with the flatter curves of the surface of the plain, often meeting the latter at an angle. The valleys are regarded as younger than the plain because in no single instance do they contain sediments that have been derived from the adjacent plain. Along the margin of the plain their filling is always of the same material as that with which the plain itself is covered—usually Ordovician limestones. The forms of the valleys and their relations to the plain are such that they would not be attributed to marine erosion.

Origin and age of the peneplain surface.—It is conceivable that during the transgression of the Ordovician sea the earlier surface, of subaerial origin, may have been replaced by one of marine planation, assuming a time interval long enough. It is now generally admitted that during a time interval of sufficient duration to permit the formation of a plain of marine planation of any considerable breadth the land of a very much larger area would be reduced almost to base level by subaerial processes. If so, temporarily assuming that the margin of the peneplain from which the Paleozoic sediments are known to have been removed owes its plain character to marine planation, it would follow that the interior portions were principally of subaerial origin. If the marginal portion of the plain owed its plain character to marine erosion, we should expect to find the débris removed from the ridges deposited in the hollows, since the waves and currents tend always to produce an evenly graded floor. In the field no trace of this has been found. The Ordovician limestones often rest directly upon the plain surface and pass down into the adjacent hollows, where the sides are not very steep. Where they are steep the lower beds abut against the valley walls and are conformably overlain by beds which rest upon the plain. No accumulation has been reported which can be regarded as distinctively a product of marine planation. Fossils (corals, crinoids, orthoceratites) are found in the lower limestone beds, sometimes within a few inches of the Archean rock, in some cases actually attached to it. From the fact that these are not comminuted it may be inferred that the conditions of transgression, at least in the localities where they occur, were such that the waters were moderately quiet; and from the absence of arenaceous deposits in many of the localities it may be concluded that the rate of transgression was comparatively rapid—presumably too rapid to permit significant marine planation.

Thus, although the area must have been exposed to marine planation at the time of Ordovician submergence, there is reason to believe

that the conditions of submergence were such that the preexisting surface, which must have been of subaerial origin, can have been but little modified. The distribution of overlying areas of Paleozoic sediments suggests that the relatively rapid depression which continued through Ordovician time continued until near the close of the Silurian, and it is probable that the middle part of the plain was completely submerged. The eastern and western parts of the plain were then still above water level. If the middle portion was completely submerged at this time it must have been reelevated and the sedimentary cover in part removed, for Devonian corals have been found in the Hudson Bay basin with their bases attached to bosses of Archean rocks. The Devonian sandstones flanking the peneplain also suggest that the middle portions of the plain were subject to subaerial degradation during at least a portion of Devonian time. Of the history of the greater part of the region from the close of the Devonian to the beginning of the Pleistocene there is no sedimentary record closely associated with the peneplain.

It has been shown that the late Mesozoic was a period of extensive peneplanation throughout most of North America. In New York and Pennsylvania to the south, in Wisconsin and Michigan to the southwest, the remnants of the planation surface have been recognized. In the far Northwest, strata classed as Cretaceous are found resting, apparently, upon the peneplain surface. It is not at all impossible that the peneplain of the central parts may be of Cretaceous age. The margins of the plain where it passes under the earlier sediments must be of earlier date. The southern margin of the plain, south of Methy Portage and around to the city of Montreal, is probably of Paleozoic (and pre-Paleozoic) age, since there is little doubt that it was once covered with Paleozoic sediments. Whether this is true of all that section which lies between the outliers before noted as occurring in the basins of a number of lakes near the central divide seems doubtful. The more detailed study of these basins may show that the Paleozoic sediments which they contain, and which are in every case except that of Lake Nipigon significantly below the level of the peneplain, are preserved because they were thrown into their present protected positions by the downthrow of graben blocks. If so, the probability that the plain is of Cretaceous age will be strengthened. What seems to be a comparable case is known in Scandinavia. The earlier sedimentary rocks were dislocated by a series of faults; later planation left only a few small patches at base level upon the downthrown parts of tilted blocks. Subsequent elevation of the whole area, and erosion of these softer remnants, produced a series of depressions in some of which are still found isolated patches of the softer rocks. The lower portions of these depressions frequently form lake basins, the most important of which are Boren, Roxen, Glan, and Braviken. Professor

Kemp has noted the occurrence of areas of Paleozoic sediments, preserved by the downfaulting of Archean blocks in New York State.[a]

So far as the geological record is known, it appears that the Labrador portion of the peneplain has never been submerged since Paleozoic time. To this long exposure to subaerial erosion may be attributed the extremely low average gradients of approximately 1 foot per mile, the lowest found anywhere upon the plain.

Departures from the normal peneplain type.—On an area reduced to a peneplain one would expect to find a gently undulating surface on which the larger streams meandered in broadly open valleys. Their power to erode would long before have begun gradually to diminish, in part by reason of the lessened rainfall due to the reduced elevation above sea level, in part by reason of the reduced grade. Their sluggish character, diminished water supply, and low velocity would not enable them to transport the waste of the land except in a very fine state of division, or in solution. Hence the surface of a normal peneplain would consist of mantle rock of considerable depth, at the top fine in texture, gradually changing with depth to unaltered bed rock. A very even surface, deep soils, streams which have long lost the adjustments of early maturity, the absence of lakes, and an elevation little above sea level must be characteristic features of a land surface which has been reduced to a peneplain by subaerial degradation.

We have already seen that the Laurentian peneplain exhibits to a most marked degree the even sky line and low-surface gradients. We find, however, that it is almost devoid of mantle rock in situ. That which occurs, with the exception of an exceedingly small amount, almost too small to notice, was brought to its present location by glacial or aqueous processes of transportation. The drainage over most parts of the area is not well established. Rapids and waterfalls are the most characteristic features of all the streams. The entire surface of the country is dotted with lakes, which are practically numberless; in places their area approaches 25 per cent of the whole, and finally, parts of the peneplain are not now in accordant position with respect to sea level. Thus, although the complicated and contorted rocks of the region are everywhere truncated by a surface which presents a remarkably even sky line, in almost every other respect the features of the area differ from those of a peneplain. Since its production the peneplain surface has undergone profound modification, leading to the production of the present features.

Origin of the basins, valleys, and gorges.—The minor basins on the upland surface, now containing small lakes, undoubtedly owe their origin to processes of differential disintegration and subsequent erosion and denudation by some agency. The last denuding agent in operation was, of course, the Pleistocene ice sheets. There is some question,

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[a] Eighteenth Annual Report, New York, Part V, pp. 143 ff.

VIEW ON THE UPPER THELON RIVER FROM CAIRN HILL, DISTRICT OF McKENZIE.
Photograph by J. W. Tyrrell, 1900.

THE LABRADOR SECTION OF THE PENEPLAIN. SIX MILES UP POVUNGNUITUK RIVER, ON THE EAST COAST OF HUDSON BAY, LOOKING INLAND. ELEVATION ABOUT 50 FEET.
Photograph by A. P. Low, 1894.

however, as to whether the denudation of the surface is due to these ice sheets or to some earlier ice sheet, or to some other cause.

The origin of the valleys and gorges incised beneath the plain to a significant degree presents some features of particular interest. Those in which the so-called Cambrian sediments lie may be older than the sediments which they contain and would thus probably be of much earlier date than the main peneplain surface. On the other hand these sediments may have been preserved by the downfaulting of a graben block before the period of planation, and the valley would then be due to the subsequent erosion of the softer sediments. The gorge-like valleys free from Paleozoic sediments and the canyons, one would be inclined to think, date their origin from a time subsequent to the planation period. Their immature form, as compared with the broader presedimentary valleys, and the absence of any Paleozoic sediments between their walls suggest this.

The processes by which they were excavated no doubt were various. Mention has already been made of the opinions of Agassiz and Bell, that some of them owe their origin to the erosion of soft, disintegrated dike rocks. This may be true in a few isolated cases. In the great majority of cases, however, particularly of the larger of these gorges, other and more general processes must have been in operation.

Given time enough there can be no question that the normal processes of river erosion could produce these deep canyons or steep-sided valleys. So far as we know at present, this seems to have been the process by which most of the deep gorges and canyons cut below the level of the Labrador peneplain were excavated. Mr. Low notes, with respect to the canyon of the Hamilton just below the Grand Falls, that the river in its erosion of this gorge has been guided by two series of joint fractures, so that the canyon has a somewhat zigzag course. Mr. Low has also drawn the writer's attention to the fact that there are several instances where an old valley has been blocked by glacial débris, and the streams flowing in the upper portion of the valley are turned aside and have already cut well-defined canyons, in some cases of considerable length, in the crystalline rocks. It is to be noted that the canyon of the Hamilton River enters a larger, broader valley, to which reference has already been made, from the north side. The old valley continues inland for a considerable distance beyond the junction of the present Hamilton River, via the canyon, with the lower part of the stream in the older valley. Mr. Low regards this canyon as of post-Glacial origin and as due to the erosion by the large stream which now rushes through it.

In the production of the many canyons that are found in different parts of the region no doubt many processes were in operation at the same time or at different times. Some of the valleys tributary to the St. Lawrence River from the northwest may be of antecedent origin.

On the other hand, it is possible that some of them are the valleys of superposed streams and owe their present courses to the initial directions taken by consequent streams long before the Paleozoic cover was removed from the present margin of the area.

PHYSIOGRAPHIC CONTROLS

One of the most interesting problems for study presented by the Laurentian peneplain is the control which the type of topography here developed has had upon the occupation and exploration of the region. Stretching as it does from the frozen arctic to the temperate regions of central Ontario, and from the ocean border on the east to the mid-continental region of the great plains on the west, in its different parts it presents many aspects indicating the operation of climatic controls which affect its flora, its fauna, and its human occupation.

The uplands of Labrador and the far northwest region (northern Keewatin and northeast Mackenzie) are devoid of trees, the vegetation being confined to the lower orders of plants. Next southward we find the belt of conifers stretching across all the region from Hamilton Inlet to Great Slave Lake, the trees increasing in size and variety with decrease of latitude. In the central parts deciduous trees abound. Although in general throughout the region we find uniformity of features, in structure and development there is a great diversity of detail. The enormous number of lakes and streams, the widespread distribution of the forests, the general uniformity of the topography, and the climatic characteristics of the region, have all contributed to make it the home of those animals whose flesh is valuable for food, and of those whose pelts are valuable for clothing or as articles of commerce. The remarkably even character of the topography of the region, the character of the flora, and the protection offered by the climatic conditions even now make possible the existence of those vast herds of caribou (comparable to the herds of buffalo which roamed the great plains of the West until after the advent of the destructive white man) which at the present roam over the barren grounds.

The Indian inhabitants of the region, living chiefly on the products of the chase, have here from time immemorial found their hunting grounds. The numerous lakes and streams then, as now, were the only lines of communication in all that vast area. Their distribution through all parts of it and the comparative ease with which traverses from one body of water to the next can be made, enabled these people to wander unimpeded over the whole region. The customs of these people in the several parts of the area differ but little; in language there are greater differences, but over very large areas the speech is the same. Probably nowhere else over so large an area have scattered communities retained so well their communal characteristics.

In language, customs, and culture they differ greatly from the various tribes found in the mountainous districts of British Columbia. In some of the unexplored parts of the region there are Indians who have not yet seen a white man, unless perhaps some half-breed trader.

On the other hand, to the average white man, with his different modes of living, the region, with its exceedingly limited agricultural possibilities, has always been inhospitable. He has displaced the native Indian inhabitants in the fertile plain regions which border the peneplain area to the south and west. The last remnants of some of these displaced tribes still survive upon these uplands, and still eke out a more or less precarious existence on the products of the chase. To the white man, however, the region offers other inducements which lead to the temporary occupation of local areas. The degradation which produced the peneplain has not only made possible the widespread forest, but has exposed mineral deposits that otherwise would not have been accessible. The region is thus of great importance as the source of almost a world's supply of timber and of the products of the mine, more particularly of the ores of iron and copper.

The character of the country makes the continued existence of the fur-bearing and game animals possible. The widespread distribution of these animals, the chief support of the inhabitants, has led to the scattering of the people over the whole area and to the development of more or less nomadic habits and customs.

The journeys of the early explorers across the region were possible because of its peculiar topographic features. These journeys were undertaken by the early missionaries almost always, and by the fur traders frequently, to visit the wandering Indians scattered throughout the region. The fur traders often undertook journeys solely for the purpose of hunting. The stories of the travels of these early missionaries as told by Parkman and others, and the histories of the great fur companies, incidents of which form the historic foundation of many tales, afford some of the most fascinating chapters in the history of Canada, and in the study of the physiographic controls of this region. The early explorations of the eastern, central, and southern part of the western arm of the area were made largely by the missionaries and the employees of the great trading companies. The exploration of the far Northwest, on the other hand, with the exception of the three years' adventurous wanderings of Hearne, an employee of the Hudson Bay Company, were only incidental to the continued search for a possible northwest passage.

The climatic conditions of the far Northwest and the absence of soil in any considerable amount from the Labrador areas and the country just north and west of Lake Superior means that these regions will always be shunned by the majority of white men in search of a permanent abode. There are, however, considerable areas where there

BARREN GROUND CARIBOU ON DOOBAUNT RIVER, WESTERN McKENZIE.
Photograph by J. W. Tyrrell, 1893.

REAT SLAVE LAKE, LOOKING NORTH FROM FORT SMITH, DISTRICT OF McKENZIE.
Photograph by J. W. Tyrrell, 1900.

and the sediments of the young coastal plain, the latter being superposed upon the former. This young coastal plain borders Hudson Bay on all sides, and the consequent drainage from the interior has incised well-defined valleys in the soft marine and glacial deposits, the interstream areas being little dissected. This modern coastal plain is of varying width up to a maximum of nearly 100 miles.

The denuded peneplain surface, although destitute of mantle rock in situ, is strewn with glacial débris often in considerable amount. In the interior of Labrador this material is often very coarse, consisting of huge blocks and bowlders, with, however, considerable amounts of finer débris. In the region south of James Bay, particularly in the Moose River basin and as far south as the Height of Land, the plain is almost completely buried beneath modified and unmodified glacial drift. Glacial drift in less amount, often fine textured, at times coarse rock débris, occurs over the whole of the western portion of the peneplain. There are, however, areas of considerable extent where the amount of drift is very limited.

In the Labrador region there is a limited forest growth in the hollows. Most of the interior is bare and barren. In Quebec and in Ontario south of James Bay the region is densely forested. The forests extend over the western portion of the plain to a short distance north of Great Slave Lake. Beyond this region is a treeless, moss-covered tundra. South of the forest line are large areas floored with glacial drift, that form muskegs, or swamps, above whose surfaces crystalline ridges and glacial kames and eskers project.

The physical features and the climate of the area are such that a large portion of it will never be occupied by permanent inhabitants. Mining interests will lead to the temporary occupation of limited areas. Other areas of comparatively small extent, where the peneplain surface is buried beneath later glacial clays and sands, which lie within the wheat belt, will probably become the home of a large population after the more accessible areas of the great plains to the west are fully occupied. The occupation of these areas will be facilitated and hastened by the construction of the proposed Grand Trunk Pacific Railway, a commercial enterprise which has become possible because of the extensive peneplanation which this area has undergone.

ÉVOLUTION MORPHOLOGIQUE DES KARPATES MÉRIDIONALES

Par E. DE MARTONNE
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On sait que les Karpates sont généralement considérées comme un des anneaux de la chaîne des montagnes de plissement tertiaire qui traverse l'Europe et l'Asie. Les Karpates méridionales, qui forment une série de hauts sommets dépassant 2,500 mètres et séparant la Hongrie de la Roumanie, semblent cependant, d'après les travaux les plus récents, avoir subi une évolution qui ne rentre pas très bien dans le cadre de l'histoire commune des chaînes alpines.

Grâce aux travaux de MM. Hauer, Inkey, Primics, Schafarzik, Nopsca, en Hongrie; Stefanescu, Mrazec, Popovici-Hatzeg, en Roumanie, on connaît maintenant les grandes lignes de leur structure géologique. On possède pour une bonne partie de cette région très sauvage et d'un accès difficile des cartes topographiques suffisantes.[a]

CARACTÈRES DU RELIEF DES HAUTS SOMMETS

Bien que ne comprenant pas le sommet le plus élevé de la chaîne des Karpates, notre région en est la partie la plus élevée comme altitude moyenne. Les surfaces supérieures à 2,000 mètres y sont très étendues et les sommets dépassant 2,400 mètres sont nombreux. De brusques dénivellations font fréquemment descendre le sol de 1,000 ou 1,500 mètres sur un espace de quelques kilomètres (versant nord des Fogarash, vallées de Prahova, Lăpuznic, Jiul romănesc). Ces traits de structure générale, qu'on peut observer sur une carte d'ensemble d'échelle moyenne, éveillent naturellement l'idée de montagnes très déchiquetées de type alpin.

Tel n'est pas cependant le caractère du relief des Karpates méridionales. Lorsqu'on atteint leurs sommets on n'y rencontre pas d'habitude les formes pittoresques caractéristiques de la haute montagne. Ce sont généralement de larges croupes herbeuses qui dominent, tellement uniformes d'aspect qu'il faut un œil exercé pour reconnaître même les cimes principales. Les contrastes violents de relief ne se

[a] Carte autrichienne à 1: 75,000 pour la Hongrie; carte roumaine au 1: 50,000; levés topographiques de l'auteur pour un certain nombre de points du versant roumain où la carte n'est pas faite.

présentent que dans trois cas: sur le rebord de quelques vallées très profondes, dans les régions de cirques glaciaires, et sur les flancs de quelques massifs calcaires. Ils sont toujours limités.

Ce caractère des Karpates a été noté par plusieurs auteurs; c'est celui de ce qu'on appelle souvent les moyennes montagnes (Mittelgebirge). On le trouve en Europe dans la zone des massifs Hercyniens ne dépassant pas 1,600 mètres (Vosges, Forêt Noire, Monts de Bohème). Il est assez singulier de le retrouver ici dans des montagnes qui atteignent 2,500 mètres et présentent des dénivellations telles que celles signalées plus haut.

Le massif du Paringu dont j'ai levé la carte au 1:25,000 offre déjà, dans sa partie orientale, un bon exemple des formes plates des hauts sommets. Mais ce caractère devient plus frappant dans le massif Banatique (région des sources de la Czerna, du Jur et du Strell). Le Boresco y forme une sorte de table, où, sur plusieurs kilomètres carrés, le sol ondule entre 2,650 et 2,050 mètres. Le plateau se suit aisément dans le Retyezat méridional, le Ţarco et le massif du Godeanu, entamé par des vallées profondes de 1,000 mètres qui n'en rompent que superficiellement la continuité. On le retrouve dans les monts du Vulcan entre 1,600 et 700 mètres, dans les montagnes de Hermannstadt autour du Surian. Dans les Fogarash même, qui sont la partie la plus élevée des Karpates méridionales, j'ai observé entre la chaîne principale qui porte toute une série de pics dépassant 2,500 mètres et le rebord méridional du massif culminant à 1,500 mètres au mont Frunte, un vaste plateau découpé en crêtes parallèles par de profondes vallées, qui s'abaisse régulièrement vers le sud de 1,900 à 1,200 mètres. Je propose d'appeler cette surface plateforme des hauts sommets, ou plateforme Boresco.[a]

ORIGINE DE LA PLATEFORME DES HAUTS SOMMETS

Ce rapide aperçu suffit pour faire reconnaître que cette plateforme se rencontre à des altitudes variées, tantôt formant réellement les cimes (Boresco), tantôt dominée par des crêtes déchiquetées (Fogarash, Retyezat).

Elle n'est pas en rapport avec la nature des roches. Si souvent elle rappelle par ses ondulations molles les formes classiques des dômes granitiques ou gneissiques, on constate qu'elle s'étend sur toutes les variétés de schistes cristallins. Elle nivelle même des terrains sédimentaires récents. L'étude du massif du Ţarco est à cet égard du

[a] Quelques-unes des feuilles de la Carte autrichienne au 1:75,000 permettent de suivre à peu près la plateforme, lorsqu'on connait ses caractères (feuilles Sebes, Klopotiva, Paroşin particulièrement). Sur le territoire roumain à peu près toute la région intéressante n'est pas encore levée (à part mon levé du Paringu au 1:25,000). De nombreuses photographies et panoramas dessinés à la chambre claire me permettent d'y suppléer. Ces documents seront publiés incessamment dans un travail assez étendu sur la morphologie des Karpates méridionales.

plus haut intérêt. La table du Boresco s'y poursuit avec une telle continuité que, de loin, le massif barre l'horizon comme une ligne droite. Il est cependant constitué par les micaschistes, des conglomérats paléozoïques, des grès et schistes liasiques, et des calcschistes jurassiques, le tout vigoureusement plissé. La plateforme nivelle même au Stenuletye et à Soarbele des calcaires crétacés également plissés.

Il est évident qu'on a affaire à une surface d'abrasion. Son irrégularité ne semble pas s'accorder avec l'hypothèse d'un nivellement par l'érosion marine. Aucun dépôt transgressif ne s'observe à sa surface. On doit la considérer comme une ancienne pénéplaine; ou plus exactement comme une surface d'érosion continentale, où l'évolution a été poussée jusques et au delà du stade de maturité.

IMPORTANCE DU PLATEAU DE MEHEDINȚI

Il est un point des Karpates méridionales encore peu connu où l'on retrouve la plateforme des hauts sommets, à une altitude beaucoup plus basse et avec des lambeaux de sédiments récents dont l'étude offre le plus grand intérêt. C'est le plateau de Mehedinți, large table cris alline de 500 mètres d'altitude moyenne, compris entre le défilé des Portes de Fer au sud, les cimes des monts de la Czerna à l'ouest, les collines tertiaires d'Olténie à l'est et le Motrusec au nord.

Il est difficile de trouver un exemple plus typique de pénéplaine. La tectonique ancienne (plis dirigés NNE.-SSO. et déjetés vers l'est) pas plus que la nature des terrains (schistes cristallins, grès et schistes liasiques, calcaire jurassique) n'y ont d'influence sur le relief général. Des sommets isolés connus dans le pays sous le nom de Cornet, qu'ils soient calcaires ou cristallins, s'y dressent, témoins de la première période d'érosion. Des vallées en gorge y rendent les communications très difficiles.

Sur la bordure orientale court une frange de conglomérats miocènes (tartanien) inclinés de 15 à 25° vers l'est, affectés par une flexure parallèle à leur limite occidentale, et recouverts en transgression par les dépôts pontiens presque horizontaux, qui forment presque toute la région des collines valaques à l'ouest de l'Oltu. Ces circonstances permettent de conclure à un soulèvement du plateau de Mehedinți, à la fin du miocène, et certains détails, dans lesquels il n'est pas permis d'entrer ici, indiquent que le pliocène marqua une nouvelle période d'exhaussement à laquelle prit part d'ailleurs toute la région des collines tertiaires de la Valachie occidentale.

Les mêmes mouvements ont affecté tout l'ensemble des Alpes de Transylvanie, mais avec une amplitude beaucoup plus grande. Le plateau de Mehedinți est resté notablement en arrière; une faille très bien marquée encore dans la topographie le sépare des hauts sommets des Karpates.

DISTINCTION ENTRE LES ALPES TRANSYLVAINES ET LA RÉGION DU FLYSCH KARPATIQUE

Tous les faits révélés par l'enquête géologique sur la stratigraphie et la tectonique des Karpates méridionales conduisent à une conclusion qui est pour nous d'un grand intérêt. Les vallées de Prahova et Dâmbovița marquent une limite architecturale d'une importance capitale entre deux régions de structure et d'histoire entièrement différentes: à l'est la région du Flysch karpatique dont le relief est dû à des plissements datant du miocène (sarmatique principalement) et se prolongeant jusqu'au pliocène; à l'ouest la zone de massifs cristallins et secondaires dont l'ensemble constitue ce qu'on appelle généralement Alpes de Transylvanie, et qui nous occupe spécialement ici. Cette région a subi deux périodes de plissement, dont la première doit être placée à la fin des temps primaires, et avait déjà esquissé toutes les lignes directrices; c'est à elle que doit être rapportée la tectonique des schistes cristallins. Une seconde période de plissement date de la fin du crétacé et s'étend même peut-être sur l'éocène; c'est à elle que doit être rapportée la tectonique des formations secondaires pincées souvent en plis aigus dans les schistes cristallins, et épousant l'orientation des lignes directrices des plissements primaires.

DATE DE LA PLATEFORME BORESCO

La période de formation de la plateforme Boresco ou des hauts sommets serait donc le début des temps tertiaires jusqu'au miocène supérieur. Elle suffit largement pour faire disparaître toute trace saillante de l'ancienne tectonique. Les orientations seules étaient conservées dans le tracé des rivières et des vallées principales, et dans la position des chaînes de collines un peu plus élevées restées en saillie, soit à cause de la nature de leurs matériaux (granite du Retyezat, calcaires des monts du Vulcan, etc.), soit à cause de leur situation par rapport au réseau hydrographique (crête des Fogarash, Haut Paringu, etc.).

Les débris de l'ancienne chaîne, encore assez élevée jusqu'à l'éocène, avaient servi à former les sédiments détritiques du Flysch karpatique. Ils s'étaient accumulés encore pendant le début du miocène dans des petits bassins situés sur la bordure du massif cristallin ou dans des vallées envahies par la mer (bassin de Petroseny).

Le plissement de la zone du Flysch ne pouvait manquer d'avoir son contrecoup sur le massif des Alpes Transylvaines. Commencé dès l'helvétien, il atteint son maximum vers la fin du miocène (sarmatien). C'est à ce moment que le massif ancien cède enfin à la poussée générale et subit un soulèvement en masse, des failles marquant presque partout la limite de la région exhaussée. La dénivellation de ces failles ne semble pas en général considérable; en sorte qu'il faut admettre un gauchissement de la plateforme ancienne. Les bassins

sédimentaires récents localisés à l'intérieur, dans d'anciennes vallées qui étaient elles-mêmes des fossés tectoniques, ne participent que faiblement au mouvement et sont par suite plissés (bassin de Petroseny, bassin de Brezoiu-Titesti). Le gauchissement de la plateforme ne va d'ailleurs pas sans des ruptures partielles. Certaines portions restent même notablement en arrière comme le plateau de Mehedinţi.

L'érosion partout ranimée commence à creuser les vallées en gorge qui découpent l'ancienne plateforme des hauts sommets.

PLATEFORME DES VALLEES

Cette histoire ne rend pas encore un compte exact de la structure des Hautes Karpates. Il pourrait paraître étrange que depuis le sarmatien l'érosion n'ait point eu le temps d'élargir les vallées principales et que le désaccord entre le relief sénile des hauts sommets et la jeunesse des dépressions soit encore si marqué dans la plupart des cas. Il n'est pas vraisemblable que la plateforme du Boresco ait atteint son altitude actuelle dès le sarmatien. En outre cette plateforme n'est pas la seule qu'on observe dans les Hautes Karpates.

Dans les Monts du Vulcan, si l'on peut gagner un sommet élevé permettant une vue transversale dans l'axe des vallées principales (Oslia, par exemple), on observe une sorte de terrasse particulièrement nette dans la vallée de Bistriţa, s'abaissant vers le sud de 800 à 400 mètres. L'absence de carte topographique rend malheureusement très difficile de suivre cette plateforme plus récente moins régulière et moins étendue que la plateforme des hauts sommets.

La vallée de l'Oltu dans sa percée à travers les Karpates s'élargit un moment au milieu du curieux bassin sédimentaire de Brezoiu-Titesti. La mer du Flysch avait pénétré là du cœur de l'ancien continent jusqu'à l'éocène. Les sédiments clastiques qu'elle y a déposés sont vigoureusement plissés. Cependant, d'un point élevé (Foarfeca, par exemple) on remarque que tout l'ensemble du bassin est nivelé par une plateforme ne dépassant pas 800 mètres découpée en mamelons irréguliers et même parfois en crêtes étroites par une multitude de vallons d'erosion récents.

On pourrait citer encore d'autres exemples. Il reste beaucoup à faire pour l'étude de cette seconde plateforme. Mais son existence ne peut être niée.

On voit que depuis le soulèvement miocène du massif ancien, l'érosion avait eu le temps d'élargir partiellement les vallées et de ramener le relief général du niveau de base, soit dans les régions de couches clastiques récentes (bassin de Brezoiu), soit dans certaines parties du massif ancien probablement moins soulevées (Monts du Vulcan, probablement une partie du Plateau de Mehedinţi).

MOUVEMENT PLIOCÈNE—DERNIER CYCLE D'ÉROSION

L'explication du relief actuel postule un nouveau mouvement de soulèvement dont la date doit être vraisemblablement placée à la fin du pliocène. On doit lui reconnaître, encore plus qu'au précédent, le caractère d'un exhaussement en masse, affectant même les bassins intérieurs à demi nivelés par le cycle d'érosion mio-pliocène. Un léger plissement des couches tertiaires sur la bordure méridionale, sensible de plus en plus vers l'est, montre que ce mouvement est encore un contrecoup des plissements karpatiques.

Le cycle d'érosion inauguré par ce nouveau soulèvement qui porte à 1,800 ou 2,000 mètres l'exhaussement total de la plateforme des hauts sommets dans ses points les plus élevés, dure jusqu'aux temps actuels. Absorbés par le travail d'approfondissement de leur vallée au sein de terrains compacts, et la formation de leur profil d'équilibre, les rivières n'ont pas encore élargi leurs vallées, et la plateforme des hauts sommets est restée en maints endroits intacte, entaillée seulement par des gorges profondes. La plateforme des vallées, due au cycle d'érosion mio-pliocène, est déjà si ravinée dans les régions sédimentaires qu'on ne peut la reconnaître que de certains points élevés convenablement situés. Elle se conserve dans les formations calcaires (Bistriţa, environs de Predeal).

PÉRIODE GLACIAIRE; SON INFLUENCE SUR LE RELIEF DES HAUTS SOMMETS ET SON RAPPORT AVEC LE SOULÈVEMENT PLIOCÈNE

La glaciation des sommets les plus élevés des Karpates méridionales paraît avoir été due en partie à ce mouvement récent d'exhaussement. Sans lui les Karpates n'auraient pas atteint, même à l'époque du refroidissement le plus marqué du climat européen, l'altitude des neiges éternelles. Le relief très adouci de la plupart de hauts sommets était favorable à la formation de grands champs de neiges; et d'un autre côté, il est assez vraisemblable que ces champs de neige ont contribué à la conservation de la plateforme des hauts sommets. Les têtes de source vigoureusement affouillées de torrents alors en pleine activité étaient prédisposées à devenir le lieu de formation de névés assez épais pour donner des glaciers même au voisinage de la limite des neiges éternelles. Ainsi, tous les massifs dépassant 2,000 mètres ont été le siége de glaciers de type pyrénéen, qui y ont sculpté des cirques, conservés encore pour la plupart dans un état si parfait que le Paringu et le Retyezat, par exemple, méritent de devenir classiques pour l'étude des cirques glaciaires. Aux cirques sont dûs tous les escarpements et tous les violents contrastes de relief des hautes cimes.

CLASSIFICATION DES TYPES DE HAUTS SOMMETS KARPATIQUES

La position des cirques par rapport à la plateforme Boresco donne l'élément d'une classification des types de hauts sommets karpatiques. Tantôt les cirques sont entaillés dans la plateforme des hauts sommets, et on a alors une montagne à sommet plat où les formes alpines sont limitées aux cirques, et où, par suite, un versant paraît généralement beaucoup plus abrupt. Le Boresco est le type parfait de pareils massifs.

Tantôt, au contraire, les cirques sont entaillés dans des hauteurs dominant la plateforme des hauts sommets, comme la crête des Fogarash. Les vallées glaciaires descendent jusque sur la plateforme qu'elles entaillent plus ou moins profondément, mais les cirques typiques se trouvent plus haut. Pressés sur les deux versants de la crête, ils la découpent et la rongent, ne laissant subsister entre eux que des arêtes étroites et des cimes déchiquetées, donnant à la montagne un aspect franchement alpin.

Tous les hauts massifs des Alpes de Transylvanie rentrent dans l'un ou l'autre de ces deux types, ou représentent la transition de l'un à l'autre.

On reconnaît aisément que le type Boresco et le type Fogarash sont en rapport avec toute l'histoire morphologique des Karpates méridionales. Le premier est réalisé là où l'ancienne plateforme des hauts sommets a été portée à des altitudes supérieures à 2,000 mètres, et n'était dominée par aucune hauteur importante. Le type Fogarash est réalisé au contraire là où l'évolution du premier cycle d'érosion tertiaire n'avait pas abouti à la disparition de tout relief. La crête des Fogarash, burinée par les cirques glaciaires, comme celle du Retyezat, représentait une chaîne de collines à la surface de l'ancien continent, au début du miocène, avant le soulèvement en masse dont le dernier épisode se place à la fin du pliocène.

CONCLUSION

En résumé, les traits du relief actuel des Alpes de Transylvanie ne sont pas ceux d'une chaîne de plissement récent, mais d'un massif ancien dont l'histoire diffère du reste de la chaîne karpatique.

Après deux périodes de plissement, dont la dernière se place à l'aurore des temps tertiaires, la région avait été réduite à un état voisin de celui d'une pénéplaine (plateforme Boresco), lorsque les plissements de la zone du Flysch eurent comme contrecoup un soulèvement en bloc du massif ancien, avec gauchissement de la plateforme Boresco. Un nouveau cycle d'érosion (mio-pliocène) nivelle certaines régions, mais est interrompu par un nouvel exhaussement à la fin du pliocène. Le dernier cycle qui a creusé les vallées actuelles dure

jusqu'à l'époque glaciaire, qui achève de donner aux Hautes Karpates leur aspect actuel, en burinant les cirques dans les massifs supérieurs à 2,000 mètres.

Cette esquisse de l'histoire des Karpates méridionales est encore fort imparfaite; nul n'en a plus conscience que son auteur. On ne saurait s'en étonner si l'on songe que la plateforme des hauts sommets, la plateforme des vallées, la pénéplaine du plateau de Mehedinţi, ne sont connues que depuis moins d'un an. L'attention des géologues hongrois et roumains concentrée sur l'étude stratigraphique, pétrographique et tectonique de cette région si compliquée et d'un accès si difficile, ne pouvait se porter sur ces problèmes. Sans leurs remarquables études on serait d'ailleurs fort empêché pour interpréter les faits morphologiques que j'ai signalés.

L'étude complète des différentes plateformes des Karpates méridionales ne sera possible que quand nous aurons pour toute la région de bonnes cartes topographiques. On pourra peut-être alors établir exactement l'étendue de la plateforme des vallées, déterminer si elle est réellement distincte du plateau de Mehedinţi, si elle se continue en dehors du massif ancien dans la zone du Flysch.

Je pense pouvoir montrer sous peu que cette dernière hypothèse est exacte, que, après la principale période de plissement karpatique, dont le point culminant est à la fin du miocène, la plus grande partie de la zone du Flysch avait subi le même sort que jadis les Alpes de Transylvanie, et que le pliocène a été marqué pour les Karpates moldaves par des mouvements plus semblables à un gauchissement général qu'à un plissement proprement dit. J'ai déjà montré que le pleistocène même a eu des mouvements du sol rajeunissant le relief de certaines régions réduites au niveau de base (dépressions subkarpatiques). Il n'est pas impossible que ces mouvements aient eu leur contrecoup, même dans la région des Alpes de Transylvanie.

On peut espérer que ces recherches, qui, dans les Karpates méridionales en sont encore à leurs débuts, ouvriront de nouveaux horizons et permettront d'expliquer en partie les difficiles problèmes d'histoire des vallées qu'offrent ces montagnes d'Europe encore si peu connues.

ISLAND TYING

By Prof. F. P. GULLIVER, Southboro, Mass.

At the beginning of a cycle following depression there will be found many islands. These will vary in form according to the stage of development reached before the drowning of the land took place, according to the structure of the region, and according to the relative amount of the sinking of the land or the rising of the water.

Whatever the form of the islands, the sea will immediately begin to attack them on all sides. Waves will form a cliff and beach at every point. Soon, however, the waste will be supplied from the cliffs faster than the sea can carry it offshore and there will begin to be some transportation of this excess of load along the shore by the currents caused by wind and tide.

Upon the ocean or more exposed side there will be the greater cutting, and the excess of rock waste thus supplied to the alongshore currents will be gradually carried to the landward side of the island and deposited in the quieter water between the island and the nearest land. Thus begins the formation of a bar of sand which will ultimately connect the island with the mainland. The writer has called this special kind of bar a "tombolo."[a]

The tombolo often starts to grow from the mainland toward the island, and sometimes the growth begins both on the mainland and on the island. The method of growth varies in different cases according to local conditions, but the principle always seems to be that the island will become connected to the nearest land by a bar of sand unless there is a strong current of water between these two land masses, which would prevent the deposition of sand, or unless the island is too far from the mainland to become tied to it.

There are many examples of islands partly or completely tied, to which reference is given in the article mentioned above. Some of the most characteristic and well known of these are the following: Gibraltar, tied to the coast of Spain; Monte Agentario, tied to the coast of Italy; Nahant and Marblehead Neck, tied to the coast of Massachusetts; several islands on the west coast of Scotland and Ireland, showing the beginnings of tombolos.

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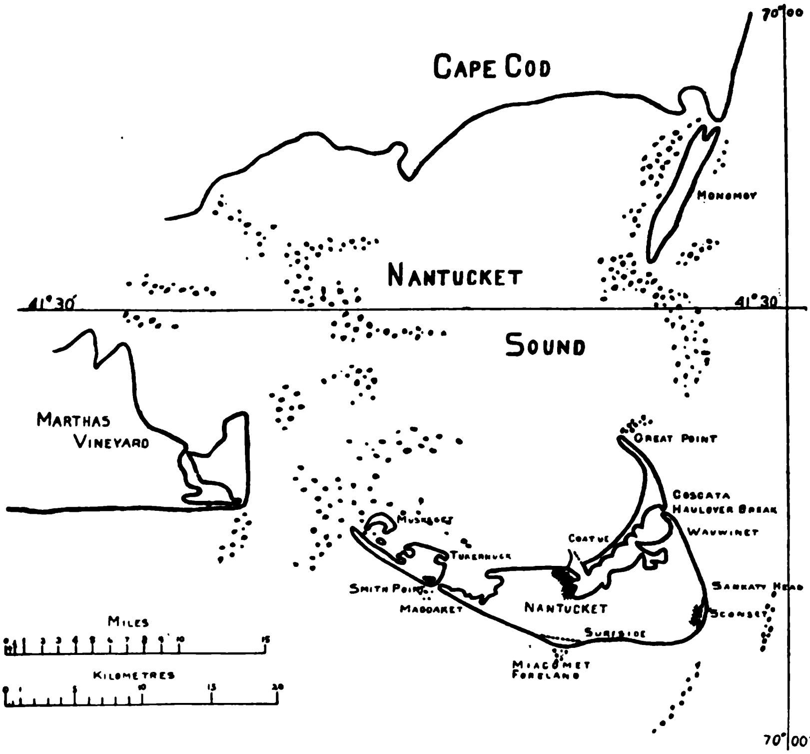
[a] Shoreline topography: Proc. Am. Acad. Arts and Sciences, Vol. XXXIV, 1899, p. 189.

From the recent study by the writer of the island of Nantucket a number of interesting points in connection with the theory of island tying have been brought out. The island of Nantucket lies too far from any other bodies of land to have the tombolos from the two ends of the island reach over to the southern coast of Massachusetts or to Marthas Vineyard; but the waste from the more exposed side of the island has built the beginnings of a tombolo on both the eastern and western ends of the island. It seems as if the sea had tried to tie the island on to the mainland and had given up the attempt, having found the currents too strong through Vineyard and Nantucket sounds and



Map of Nantucket Sound.

the distance too great to be bridged over, and had built the sand carried from the eastern and southern sides of the island into the deposits of Coatue and Tuckernuck shoal.

Great Point and Monomoy Point form two ends of an uncompleted tombolo extending from the northeastern corner of Nantucket and from the southeastern corner of Cape Cod. The great question is, will these two uncompleted portions of a tombolo ever be connected. The question whether there is or is not a tendency for the ocean to build up the sand between these two points and form a completed tombolo is of the greatest interest to the commerce of the United States, because

this is a waterway of the greatest importance to the coast trade, it having been claimed that more tonnage goes through this channel than through any other water body along the eastern coast of the United States. A series of shoals extend out in the form of a semicircle into the ocean between the ends of Great and Monomoy points which may represent a tendency to build up the sand. Of course it is possible that these shoals represent a former land mass, now worn down beneath the sea level.

Smith Point, extending from the southwestern corner of the island, represents the attempt of the sea to join Nantucket and Tuckernuck islands with Chappaquiddick and Marthas Vineyard islands. This uncompleted tombolo has gone through many changes of form since the first maps were made of this region, the currents having broken across it at many times. Muskeget Channel shows that the currents formed by wind and tide are too strong to allow the completion of this tombolo. The great irregularity of the shoals as mapped by the Coast Survey shows a constant strife between the sea on the one hand, which tries to join all these islands with a sand bar, and the currents working at right angles to the alongshore movement, which try to keep the channels between the islands open.

There is a series of shoals extending north from Tuckernuck toward the southern coast of Cape Cod, namely, Muskeget, Tuckernuck, Shovelful, Long, Norton, Hawes, Horseshoe, Eldridge, Wreck, Succonesset, Bishop and Clerks, and Senator. These shoals seem to represent the attempt of the sea to tie Nantucket and Tuckernuck islands to the southern coast of Massachusetts. The strong currents through Vineyard and Nantucket sounds have prevented the completion of any tombolo, and the sand in these shoals shows, by its complicated arrangement and by its shifting from year to year, a constant strife between the northward movement of the sand to form a tombolo and the east and west movements of the currents which try to spread the sand over the bottom of Vineyard and Nantucket sounds.

The break through the completed tombolo connecting Nantucket and Coskata islands was made in December, 1896, by a series of heavy storms at the place where the fishermen used to haul their boats from the harbor over into the ocean. This opening has moved successively northward until it is now just south of the area of clays and glacial sands which make up Coskata Island. The writer has discussed the changes and form of this opening, giving a series of drawings, in the Bulletin of the Geological Society of America.[a]

Another point brought out by the recent study of the action of the sea on Nantucket is that along the more exposed side, where in general the sea is cutting away the island, there has been a building forward

[a] Vol. XV, 1904, pp. —.

of the shore line at certain points. These forelands have been built in front of a maturely developed shore line; they project out from an earlier-made cliff that has a simply curved outline. They appear to be comparable to the sand bars in a maturely developed river, and probably represent places where there has been too great a load supplied to the alongshore currents for them to carry it either out into the deeper ocean or around the island to the quieter water on the landward side.

Two of these forelands are found on the south and east coasts of Nantucket. One of these, which the writer has called Miacomet foreland, extends 5,000 or 6,000 feet along the coast, east of Miacomet Pond and is about 1,200 feet broad at its widest point. The second has been built in front of the old cliff at Siasconset, at the southeastern corner of the island. Both of these forelands are built at places where one would expect the sea to be cutting back into the land rapidly, and on both sides of them at present there is a rapid encroachment upon the area of the land. Less than fifty years ago the sea was cutting into the land at the points where these two forelands now occur, as is well shown by the testimony of the residents of the island. The building forward of these forelands on a maturely developed shore line needs further study before it can be fully explained.

The sea seems to cut away the land at certain points and not along the whole shore line at once, according to the records of recent cutting along Nantucket. In heavy storms the cliff will be a great deal undermined and washed away at a certain point while points to the right and left are very little attacked. This fact seems to the writer to be one of the important details of wearing away of the land by the sea when a maturely developed shore line, such as is found on the south shore of Nantucket, has been developed by the rapid attack of the sea on the land. The simple curvature of the outline of the shore line will be maintained by a series of rapid attacks at different points along the coast.

COMPLICATIONS OF THE GEOGRAPHICAL CYCLE

By Prof. W. M. DAVIS, Harvard University, Cambridge, Mass.

MODERN GEOGRAPHY

In earlier times, when it was thought that the past history of the earth was of a different order from the present, it was natural enough that the geography of the lands should have been studied independently of geological methods. Now that it has been in more recent times recognized that the yesterdays of geology closely resemble the to-day of geography, and that the land forms of the present are the natural outcome of the past, it savors of an unnecessary conservatism to hold to empirical methods in geography, instead of adopting the natural methods of geology. The rational and modernized treatment of geographical problems demands that land forms, like organic forms, shall be studied in view of their evolution, and that in so far as this method of study requires the geographer shall be a geologist.

It is not enough, however, simply to see that land forms have been evolved by the interaction of internal and external agencies—that is, of forces that deform the earth's crust and of forces that carve its surface. It must be noted also that the processes of evolution are in the main orderly and that the evolved products are systematically related, for however disorderly the action of internal forces may be the forces that carve the surface carry on their work in a regular fashion and thereby produce a systematic sequence of surface forms. The forms that we see are all members of this sequence, and are therefore fittingly described in its terms.

IDEAL CYCLE

In the scheme of the ideal geographical cycle a complete sequence of land forms of one kind or another may be traced out. The cycle begins with crustal movements that place a given land mass in a certain attitude with respect to base-level. The surface forms thus produced are called initial. Destructive processes set to work upon the initial forms, carving a whole series of sequential forms, and finally reducing the surface to its ultimate form—a low plain of imperceptible relief. The sequential forms thus constitute a normal series by which

the initial and the ultimate forms are connected. As a result, the sequential forms existing at any one moment are so largely dependent on the amount of work that has been done upon them that they are susceptible of systematic description in terms of the stage of the cycle which they have reached. Moreover, the correlation of all the separate forms appropriate to any one stage of the cycle is so intimate and systematic that any single form may be designated in an appropriate and consistent terminology, as a member of the group of related forms to which it belongs, and thus better than in any other way the features of the lands may be systematically and effectively described. There is, unfortunately, not space to illustrate the principle here.

Geographers do not as a rule recognize the correlation of forms here referred to, and as a result they do not use the principle of correlation as an aid in observation and description. This is the more to be regretted when it is noted that the failure to take advantage of the principle does not arise from any objection to its correctness, but rather from inattention to it.

A statement of the scheme of the cycle in its simplest form was presented before the Seventh International Geographical Congress at Berlin in 1899. I desire here first to consider briefly a few objections that have been urged against it, and second to set forth some of the modifications by which the ideally simple scheme may be adapted to meet the complications of nature.

THE TERM "CYCLE"

Objection has been made by some German writers to the term "cycle," because the scheme is not concerned with anything circular. It is a matter of relative indifference what term is used; and if any other word would be more generally acceptable than cycle, priority of usage of this term and whatever currency it has already gained ought not to prevent the adoption of its belated superior. In any case, it is the scheme and not its name that is important; and it is a matter of regret that criticism of the latter should apparently detract from the discussion or the use of the former. If the name is, however, to be seriously reconsidered, it should be noted that there is in the English meaning of the word "cycle" a sufficient reason for its being used as the name of the scheme here considered. Webster defines it as follows:

1. An imaginary circle or orbit in the heavens.
2. An interval of time in which a certain succession of events or phenomena is completed, and then returns again and again, uniformly and continuously in the same order; a periodical space of time marked by the recurrence of something peculiar.

The ideal cycle, uninterrupted till its end, and then ready to run its course again, comes as near to its dictionary definition as need be.

The actual and incomplete cycles, of which the lands give so many examples, depart from the ideal in the various ways to be considered below, and yet constantly, so long as they endure, hold fast to the essential features of the ideal cycle.

Some geographers have felt objection to the term "cycle," because the first member of the sequence of events that it includes is thought to be unlike the last. As far as plains and plateaus are concerned, this objection does not hold, for they begin and end their ideal cycle of changes as low, featureless expanses; and if the views now coming into vogue regarding certain mountain chains prove generally applicable, as seems more and more likely to be the case, then mountains will also as a rule have low-lying plains for their initial and ultimate forms. In any event, this objection to the term is based on a subordinate feature of the scheme; its greater feature of orderly progress through a long period of time, repeated with every uplift, is the real warrant for the name.

DEDUCTIVE NATURE OF THE CYCLE

The suggestion has been sometimes made that a scheme having a less proportion of imagined or deduced elements and a greater number of actual examples would be more generally acceptable to geographers. In reply, it may be said that the scheme of the cylce is not meant to include any actual examples at all, because it is by intention a scheme of the imagination and not a matter of observation; yet it should be accompanied, tested, and corrected by a collection of actual examples that match just as many of its elements as possible. It may be added that the fear expressed by some that deduction here goes too far is an illustration of a feeling which comes from adopting a very different point of view from that occupied by those who find profit in using the scheme of the cycle. Deduction may go wrong if it be illogical, careless, or incomplete; but if correct it can not go too far. It seems to me that it would be just as appropriate to say, "in that work, observation goes too far," as to say, "in that scheme, deduction goes too far." The two processes are entirely distinct and their results should never be confused. It is as desirable to complete the one as the other. Each process may supplement or reenforce the other; but neither one can wholly replace the other, and neither one should stop until it has covered the whole ground open to its advance. From the very difference between observation and deduction as to methods and results, it is essential that any science which attempts to explain the seen by the unseen should employ both these mental processes as fully as possible. For my own part, it is just as much a desire to carry the scheme of the cycle farther toward completion by the free use of accurate deductive methods as it is to carry the collection of actual facts farther toward completion by the free use of accurate observa-

tional methods. It can not be too strongly urged that, while the results of the two methods should be carefully held apart, the two methods themselves should go hand in hand. Conscious cultivation of each method is a most desirable preparation for physiographic investigation, just as it is for physics or astronomy, and observation is greatly aided by thorough deduction, just as deduction is aided by thorough observation. To object to the scheme of the cycle because it is too deductive seems to me nothing less than a misapprehension as to the logic of the case—as well object to a report on field work because it is too observational.

SUPPOSED RIGIDITY OF THE CYCLE

It has been urged that the scheme of the cycle is so rigid and arbitrary that it can not be of service in describing the manifold phenomena of nature. This criticism is a result of regarding the ideal cycle alone, without going on to the modifications by which it is easily adapted to natural conditions; and as this misconception may have arisen either from inattention to the more advanced view of the scheme, or from too great an emphasis on the elementary statement of the scheme in the article above mentioned, it is all the more desirable now to present the scheme more fully and to consider the modifications by which it is so easily made to meet the complicated examples found in nature.

ELEMENTARY POSTULATES AND THEIR MODIFICATIONS

The elementary presentation of the ideal cycle usually postulates a rapid uplift of a land mass, followed by a prolonged still stand. The land mass may have any structure, but the simplest is that of horizontal layers; the uplift may be of any kind and rate, but the simplest is one of uniform amount and rapid completion; hence plains and plateaus have an early place in a systematic classification of land forms; but all sorts of structures and all sorts of uplifts must be considered before the scheme is completely worked out. In my own treatment of the problem, the postulate of rapid uplift is largely a matter of convenience, in order to gain ready entrance to the consideration of sequential processes and of the successive stages of development—young, mature, and old—in terms of which it is afterwards so easy to describe typical examples of land forms. Instead of rapid uplift, gradual uplift may be postulated with equal fairness to the scheme, but with less satisfaction to the student who is then first learning it; for gradual uplift requires the consideration of erosion during uplift. It is therefore preferable to speak of rapid uplift in the first presentation of the problem, and afterwards to modify this elementary and temporary view by a nearer approach to the probable truth; and this has been for some years past my habitual method in teaching.

A special case necessitating explanation by slow uplift may be easily imagined. If an even upland of resistant rocks be interrupted by broadly open valleys, whose gently sloping, evenly graded sides descend to the stream banks, leaving no room for flood plains, it would suggest slow uplift; the absence of flood plains would show that the streams have not yet ceased deepening their valleys, and the graded valley sides would show that the downward corrasion by the streams had not been so rapid that the relatively slow processes of slope grading could not keep pace with it. In such a case there would have been no early stage of dissection in which the streams were inclosed in narrow valleys with steep and rocky walls; the stage of youth would have been elided and that of maturity would have prevailed from the beginning, but with constantly increasing relief as long as uplift continued. Examples of this kind must be rare; it is nearly always the case that a beginning of flood-plain development is made before the valley sides are completely graded to even, waste-covered slopes; and hence the usual supposition of rapid uplift—rapid, as the earth views time— is probably essentially correct. Moreover, it should not be forgotten that uplift must usually be much faster than the downwear of general subaerial erosion, however nearly it may be equaled by the corrasion of large rivers. The original postulate of rapid uplift therefore requires only a moderate amount of modification to bring it into accord with most of the land forms that we have to consider.

The postulate of a still-standing land, unmoved until it is worn down to a plain, is like the postulate of rapid uplift, a matter of convenience for first presentation; but it is also something more. It is essential to the analysis of the complete scheme because only in the ideal case of a land mass that stands still after its uplift can one trace out the normal series of sequential events in which the real value of the cycle scheme consists, and thus learn the systematic correlation of forms that characterizes each stage of the cycle. It is only after the normal series has been analyzed that the peculiar combinations of forms which result from two or more cycles of erosion can be understood. The recognition of the systematic correlation of individual forms appropriate to any given stage of the cycle constitutes a marked advance over that earlier style of physical geography in which the various elements of form were described as if they had nothing to do with one another. One of the most notable features of this advance is the great increase in the interest that attaches to the study. The increase of interest is, however, a most natural result of the newer method, for interest is always aroused by closer approach to the true nature of things and by the perception that what had been mistaken for meaningless, inert forms are in reality actively engaged in a great series of meaningful changes. The marvelous interdependence of the various parts of a maturely organized drainage system must, indeed, when fully appre-

hended, awaken wonder as well as interest; but it is only under the supposition of an essentially still-standing land that the mature organization of drainage systems can be reached. Hence, however improbable a prolonged still stand of a land mass may seem, the consequences of such a condition should be followed out with care as furnishing the norm of the scheme, and hence as forming the essential introduction to all manner of complications that follow. Only after the norm has been established can the effects of various movements—uplift, depression, warping, breaking—be duly considered.

INTERRUPTIONS OF THE CYCLE

Movements of the land mass may evidently occur at any stage in the advance of the cycle. They then interrupt the further progress of sculpturing processes with respect to the former base level by placing the land mass in a new attitude as referred to the sea. The previous cycle is thus cut short and a new cycle is entered upon. Such movements are given the semitechnical name of interruptions and the partial cycles thus separated are by ellipsis spoken of simply as cycles. The effects of interruption are chiefly observable in cases where the newly opened cycle has reached a less advanced stage than that of the previous cycle at the time of the interruption, as for example, in western Germany, where the young or submature valley of the Rhine is carved in the old torso or peneplain of the Schiefergebirge; or in western Pennsylvania, where the submature valley of the Monongahela is incised in the maturely dissected Allegheny plateau. If the opposite relation obtains the more advanced work of the new cycle will obliterate the less advanced work of the previous cycle. It is in connection with interruptions that such terms as revived, rejuvenated, and drowned have come into use; they are so convenient that once adopted they are not likely te be given up. Certain it is that the conception of cycles and interruptions has been extremely fertile; it has led to the recognition and ready description of features that previously passed unnoticed, as in the case of the Pennsylvania Appalachians.

Interruptions due to simple uplift or depression have been most commonly considered, but tilting has been shown by Campbell to have appropriate consequences in drainage modifications in the eastern United States; the discussion of block faulting has been opened by Gilbert and Russell for the Great Basin region of Utah and Nevada; folding has been considered for the Alps, the Jura, and the Appalachians, and if the Jura Mountains must now be withdrawn from the class of a one-cycle folded range, they will only join the majority as an example of a region of disordered structure once worn down and now broadly uplifted and maturely dissected in a second cycle of erosion.

Certain it is that when various kinds and degrees of interruption at various stages in a cycle have been considered, the variety of possible combinations becomes so great that there is no difficulty whatever in matching the variety of nature. The difficulty is indeed reversed; there are not enough kinds of observed facts on the small earth in the momentary present to match the long list of deduced elements of the scheme. A notable example of the deficiency of observation may be noted in connection with belted coastal plains. A number of examples are known in which the upland belt or cuesta is separated from the oldland by a continuous inner lowland, with appropriate drainage by longitudinal subsequent streams, diverted consequent headwaters, short obsequents running down the infacing slope of the cuesta and beheaded consequents on the outlooking slope. The elastic scheme of the cycle easily matches these facts of observation, but there are no known examples of belted plains in earlier stages to match the several deduced phases of cuesta development which are familiarly included in the scheme of the cycle. Rigidity and deficient variety can therefore hardly be regarded as defects of the elaborated scheme of the geographic cycles.

EDUCATIONAL VALUE OF THE ELABORATED SCHEME

It is perhaps true that those who have already formed habits of study which do not include the apparently overlong deductive consideration of a scheme for the treatment of land forms may become impatient at what they regard as a too elaborate series of unpractical abstractions, and that they may prefer to treat each actual case in such a way as seems appropriate when the case arises, and thus allow a scheme of treatment to grow in the irregular order of accidental accumulation rather than in the more systematic order of deductive development. But on the other hand, those who are now forming their habits of study gain great advantage from the more thorough consideration that the scheme of the cycle gives as compared with the less systematic methods of treatment. Beginners thus take up the study of land forms in their natural, genetic relations, and discover a fullness and continuity and reasonableness of meaning where explanation would otherwise be fragmentary or wanting. Moreover, even the preliminary presentation of the ideal cycle need not be wholly deductive or abstract; it may be enlivened by the frequent introduction of actually observed examples which confirm its deductions at every stage of progress; the method of presentation may be at any time changed from deductive to inductive, and a group of observed facts for which the scheme as then developed has no match may be empirically described as a means of exciting the further extension of the scheme. The only essential is that not merely the rigid ideal con-

ception of a single cycle, but many combinations of interrupted cycles should be familiarized by discussion and illustration until they are easily carried in the mind, for as in the case of the Greek alphabet, of musical notation, or of contoured maps, so in the case of the cycle; it is only to those who reach the point of facility in using its complications that the scheme becomes of practical service in physiographic work.

VERITY OF THE CYCLE

Although it is thus shown that the complications arising from interruptions are of great practical importance, it is not true that the ideal cycle is only an abstraction. It is true that the consideration of actual examples frequently shows repeated earth movements or interruptions which result in a succession of partial cycles, some of which may be so short as to be merely brief episodes in an otherwise long history. It must not, however, be forgotten that cycles of erosion have in some cases reached at least the penultimate stage without significant interruption, for the explanation of certain uplands as now uplifted and partly dissected peneplains is supported by a large array of strong evidence. However many interruptions the earlier history of such districts may have witnessed, a long cycle of untroubled calm seems afterwards to have settled upon them, in whose advanced progress all traces of previous cycles have been obliterated. However rare it may be to find peneplains still holding to-day the attitude with respect to base-level that they must have held while they were slowly worn down, the facts of observation on partly dissected uplands find no explanation save that which carries them all uninterruptedly through the stages of short youth and longer maturity far into very long old age. Thus in these cases at least there is full warrant for the original postulate of a still-standing land mass. The verity of low-lying undissected peneplains to-day and the reasonable inference of their more common occurrence in the past belong with historical geology, where they are destined to play an important part in terrestrial physics, along with such matters as marine transgressions of widespread occurrence, like that of the Cambrian and Cretaceous seas.

NORMAL AND SPECIAL AGENCIES

Thus far it has been tacitly implied that land sculpture is effected by the familiar processes of rain and rivers, of weather and water. It is certainly true that the greater part of the land surface has been carved by these agencies, which may therefore be called the prevailing or normal agencies; but it is important to consider the peculiar work of other special agencies, namely, ice and wind. It is not to be implied that any special agency ever works alone, but that it dominates in its

time and place, as ice does in Greenland, as wind does in certain deserts, and as the rain and rivers do in better favored lands; it is indeed important to recognize that the various agencies work to a certain extent in combination, for frosty weathering and the active washing of rainy thaws on the higher peaks and ridges is a characteristic accompaniment of glacial erosion in mountain regions; and even in deserts occasional cloudbursts may provide shortlived but strenuous streams that develop and maintain valley systems, with their well organized down-hill lines, in defiance of the prevalent winds which could never alone produce any such system of coordinated and ramifying slopes. It is only recently that the conception of a whole cycle of glacial erosion has been discussed; and a whole cycle of wind erosion is as yet a relatively neglected consideration; yet it can not be doubted that both of these special ideal cycles deserve deliberate analysis, for until such analysis is made, the next step, and one of more frequent application, can not be safely taken, namely, the combination in a single cycle, uninterrupted by land movements, of a succession of normal and special agencies. Thus we come to the important complication of climatic changes.

NORMAL AND ACCIDENTAL CLIMATIC CHANGES

The normal ideal cycle postulates no climatic change except such as accompanies the decrease of surface temperatures and the increase of precipitation caused by the initial (relatively) rapid uplift and the gradual rise of surface temperatures and decrease of precipitation that accompanies the slow wearing down of the region to a lowland plain. That such climatic changes have taken place seems fanciful at first, but more deliberate consideration must change the fancy into matter of fact. It was a wild flight of the scientific imagination by which Tyndall was led to the brilliant suggestion that Alpine glaciation had decreased because the glaciers had worn the Alps down. The famous physicist mistook a short-lived climatic accident for a large part of a cycle. Yet it can not be doubted that many mountain ranges of earlier geological times have been worn down in some way or other, and that the climate of their region has experienced changes appropriate to such changes in the typography. The distribution and indeed the specific modification of land plants and land animals must have repeatedly been influenced by such changes in land forms, for while short climatic accidents, like the several glacial epochs of post-Tertiary time, were rapid enough to cause migration or extinction of organic forms, the vastly slower change of climate normal to the ideal cycle may only provoke adaptations to new conditions.

It thus appears that climatic changes of the kind that have been most discussed in geographic literature are independent of the ideal

cycle. Whether they are marked by changes from nonglacial to glacial, or from subarid to arid conditions, they occur at any stage of a cycle, and are therefore noted by the semitechnical term "accidents." The delicate shore lines of Lake Bonneville on the elaborately carved slopes of the Wahsatch Mountain block in Utah, or the relatively small terminal moraine that crosses the Cretaceous skylines, the Tertiary slopes and valley floors, and the post-Tertiary trenches in the Pennsylvania Appalachians, suffice to show how brief climatic accidents are in comparison with the cycles of erosion that wear down mountains.

VOLCANIC ACCIDENTS

Volcanic eruptions are accidents of another kind. They occur at any stage of a cycle and at any part of a surface, entirely irrelevant to the normal development and distribution of surface culture. They may reach so large a scale as to deserve the name of revolutions, as in Oregon or western India, but when of smaller dimensions, as in central France, the haphazard or accidental manner in which they interfere with the orderly sequence of normal processes is well illustrated.

THE CYCLE OF THE SHORE LINE

There is still to be considered the work of the ocean on the shore line of the lands; but here, as before, the scheme includes an initial stage, when a movement of the earth's crust gives a new position to the shore line, and a systematic series of normal sequential changes to an ultimate stage, in which all the land is worn away. This embraces all the possibilities of the ideal case. Like the processes of surface carving, the processes of shore-line development are subject to variation with climate, from the work of the ice foot in polar regions to the work of coral reefs and mangrove swamps in the torrid zone.

One significant peculiarity of the development of the shoreline is its immediate recognition of changes of level or interruptions; not only changes in the local land mass, in which case the change is shown in its full measure, but in any part of the sea bottom or sea border, in which case every seashore line is also affected in some degree. This contrast leads to the inference that the product of long-continued work of the shore-line forces on a fixed level or on a uniformly changing level is less likely to be found than the product of long-continued work in an inland region, where a series of small and frequent interruptions (elevations and depressions) might hardly make themselves felt. The contrast is still more marked between the sensitive and fluctuating shore line and the relatively fixed local base level of a large interior drainage basin, which knows nothing of elevations and depressions except in the climatic variations they may cause, and which is subject to significant change only by warping or by the development

of a drainage outlet to the sea. A case of the latter kind seems now to be in progress where the upper branches of Indian rivers are gnawing headward through the Himalayas and giving discharge to previously inclosed Tibetan basins.

The sensitiveness of a local shore line to changes in the ocean basin or border all around the world makes extensive plains of marine abrasion of improbable occurrence; but the chief reason for interpreting as subaerial peneplains those areas that were formerly explained as the work of the seashore waves is that the unconsumed residual mountains, by which peneplains are so often adjoined, have no appearance of a sea cliff along their border, and have every appearance of the frayed out base line that subaerial erosion would necessarily produce. This is admirably shown along the inner border of the Piedmont peneplain in North Carolina and Georgia, where the residual mountains of the southern Appalachians give forth rambling, sprawling spurs, that interlock with wide-open, flat-floored, ramifying valleys. Mighty as are the destructive processes of the shore line, they seem to have been too seldom allowed continued effort at a given level long enough to accomplish the great work of which they are undoubtedly capable. Richter was right in calling the coast plain of Norway, first explained by Reusch, as the greatest single piece of shore-line work of which we as yet have definite knowledge.

PASSIVE MASSES, ACTIVE AGENCIES, CREEPING WASTE

The fully developed scheme of the cycle recognizes the passive mass of the earth crust, raised here and there, and thus exposed to the destructive processes; the various destructive processes or agencies by which the passive crustal mass is systematically carved; and the waste or "chips" that result from the carving processes. The waste is much less active in its creeping and washing movements than are rivers, glaciers, or winds in their flow, and yet the waste is much more active in its down-slope movements than is the passive mass on which it rests. The cloak of creeping rock waste that covers a graded hillside is as much deserving of systematic description as is the great rock mass of the hill as a whole, or the slender thread of the stream in the valley; and the suggestive correlations that result from giving a definite place in systematic physiography to the "forms assumed by the waste of the land on the way to the sea" are sufficient warrant for this element of the scheme.

TERMINOLOGY OF THE CYCLE

It thus appears that the scheme of the simple ideal cycle may be gradually and systematically modified until its deductions cover all manner of structures, agencies, waste forms, interruptions, and acci-

dents. When thus conceived it is a powerful instrument of research, an invaluable equipment for the explorer. It is not arbitrary or rigid, but elastic and adaptable. It is a compendium of all the pertinent results of previous investigations.

A very natural accompaniment of the systematic development and elaboration of the scheme, along with the general advance of geology and geography, has been the introduction of a certain number of terms with which to name certain ideas as well as certain land forms of special importance. Cycle, stage; initial, sequential, ultimate; young, mature, old; interruption, accident; consequent, grade, adjustment, revived, drowned, and so on, are examples of ordinary nouns and adjectives thus used in a more or less new and special sense. The extension of the meaning of some of these words beyond their ordinary definitions is perfectly in accord with the normal growth of languages as an accompaniment to the growth of experience. "The ordinary processes by which words change their meanings are, then, essentially the same as the devices of poetry; or, to express the fact more accurately, the figurative language of poetry differs from the speech of common life mainly in employing fresher figures, or in revivifying those which have lost their freshness from age and constant use. Language is fossilized poetry which is constantly being worked over for the uses of speech. Our commonest words are worn-out metaphors."[a]

Other terms are new made, in the absence of any satisfactory existing words. Such are base level, peneplain, obsequent, insequent, and a very few more. It is curious to note the disturbance that these few words have occasioned. Some go so far as to say that every new term is a positive detriment to science, as if it were possible to hold the new wine of discovery in the old bottles of ignorance. Others complain that they find it difficult to remember the different meanings of similar terms, such as subsequent and resequent, consequent and obsequent; but so far as I have looked into this difficulty, it is based on unfamiliarity with the ideas here concerned rather than with the words by which the ideas are named, and the sufficient cure for the difficulty is to give a more serious and sustained attention to the subject in which the terms are employed. Even so serviceable a term as "monadnock" has been objected to because it is not English; and yet the objector may complacently accept meander and atoll and a host of other foreigners without noting that they may have once seemed as strange and barbarous to his predecessors as monadnock now seems to him. Islandmountain, literally translated from the term which German physiographers use for monadnock, is not likely to be acceptable in English usage. Peneplain has been unjustly condemned as a badly

[a] Greenough and Kittredge, Words and their ways in English speech, New York, 1901, p. 11.

formed hybrid, apparently on the ground that the Latin "pene" and the English "plain" ought not to be joined; yet this word was approved by expert philologists before it was announced, and it has a host of accepted analogues. If we happen to have kept the root in its Latin form in peninsula, we have not in promontory; peneplain is just as good as penult or promontory, in all of which the root is given in Anglicized form while the Latin form of the prefix is kept unchanged.

With regard to all this matter of terminology, I allow myself here the pleasure of reciting a personal incident. An experienced geographer expressed to me on a certain occasion about ten years ago his regret that so many new and unnecessary terms had been introduced into the study of physiography. I replied that the terms did not seem to me unnecessary or unduly numerous. Some months later my friend wrote that he had looked more fully into the matter, and added:

> It gives me pleasure to tell you that I now fully value the use of the exact terminology * * * and I beg of you kindly to excuse the remarks which I was too prompt to make * * * against the introduction of new terms.

RELATION OF GEOLOGY AND GEOGRAPHY

Some have urged that the scheme of the cycle is nothing more than a part of physical geology, and have thereby thought to criticise the scheme unfavorably. They are essentially right as to the geological quality of the scheme, but this is, to my mind, a high merit. Yet, although largely geological, the scheme of the cycle is at once something less and something more than physical geology. It is avowedly and necessarily geological, in the sense stated at the beginning of this essay, because the time is now passed when the existing forms of the land can be considered apart from those of the past or apart from the processes and the changes that have accompanied the past into the present on the way to the future. It is an obsolescent system of the sciences that would set geography apart from geology, and it is a confused system that fails to recognize the relations and distinctions between the two. Geology is in fact made up of a countless number of geographies, horizontally stratified in relation to the vertical time line; geography is, therefore, only one day's issue of the world journal whose complete file constitutes geology. Geology is, moreover, particularly concerned with changes recorded in the order of their time sequence – that is, with the historical element of earth science; geography is concerned chiefly with momentary views, and has, therefore, to do with the distribution of phenomena over the earth's surface at one time rather than with phenomena in their order of occurrence through the passing ages. Every epoch or moment of the past has had its own geography; if we associate this name chiefly with the present, it is not so much because

the geography of the present is inherently more important than the geographies of earlier times as because it is existent and visible.

The scheme of the cycle, by which land forms may be described, is, therefore, properly of a geological nature. It is, however, less than physical geology in that it does not study phenomena in their time sequence for the purpose of learning the history through which they have passed, but for the purpose of using this history in order to describe their present state. The geographer employs as much of geological methods as serves his needs in giving accurate statement of his facts; yet he remains a geographer. In the same way the chemist employs physical methods in weighing his precipitates, yet he remains a chemist.

The scheme of the cycle is more than physical geology in that it attaches great importance to form as the product of process, and to the systematic correlation of normally associated forms; while physical geology, as ordinarily treated, is largely contented with the more independent and local study of process and product. It is obvious, however, that the scheme of the cycle may be used interchangeably as a means of geological investigation or as a means of physiographic description. The upland of southern New England may, on the one hand, be described as an uplifted and maturely dissected peneplain; or, on the other hand, through the forms thus described, determination may be made of a regional uplift that might otherwise elude recognition.

PRACTICAL VALUE OF THE CYCLE

The elaborated scheme of the cycle provides a systematic, rational, genetic classification for land forms; the possession of such a classification promotes the collection and the description of observable facts; the understanding of the classification greatly assists the trained reader in appreciating the descriptions of the trained explorer. These are tests of the practical value of the cycle which may be amplified on some future occasion.

BEARING OF PHYSIOGRAPHY UPON SUESS'S THEORIES

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[Abstract.]

Suess has announced his conviction that plateaus or horsts gain their altitude with respect to neighboring lower lands not by their own local uplift but by the depression of their surroundings. The evidence for this conviction is not a direct demonstration of the depression of the lower lands, but an indirect argument based on the difficulty of accounting for the forces needed to produce local uplifts. In his great work, Das Antlitz der Erde, this distinguished geologist does not directly inquire into the altitude that various plateaus had with respect to sea level before the occurrence of the displacement by which their present altitude was gained, but it is implied that both the plateau areas and the surrounding areas formerly stood at (or about) the present altitude of the plateaus, and that the depression of the surroundings necessary to leave the plateaus in relief was limited to the neighboring areas of now lower lands.

It appears, however, that many plateaus referred to by Suess were formerly peneplains, and hence that they once stood close to sea level. It follows that if the present altitude of such plateaus was gained by the depression of their surroundings, then not only the neighboring lower lands, but all the oceans of the world and all their associated lowlands must also have been depressed by the full measure of the altitude gained by the former peneplains. It may be impossible to disprove these wholesale movements of depression, but it is desirable to recognize their areal magnitude. Until direct evidence of the occurrence of depression is found it seems more reasonable to regard the present altitude of plateaus that were once peneplains as due to local uplifts, whether in our abundant ignorance of the earth's interior processes we can explain local uplifts or not.

SCIENTIFIC EXPLORATION OF CAVES

E. A. MARTEL, Vice-President Paris Geographical Society

The United States of America possesses the longest known caves in the world. Yet, in view of the marvelous geological works of the United States Geological Survey, it is wonderful that the scientific examination of these caves has not been until now carried on more thoroughly and profitably. For, except from the zoological point of view, so notably illustrated by the investigations and papers of Packard, Putnam, Tellkampf, De Kay,[a] and others, it is no exaggeration to say that American caves have hitherto been specially considered rather as places of resort for tourists than as scientific laboratories. This is clearly indicated by the excellent book[b] written twenty-two years ago concerning the best known of such caves by the Rev. Horace C. Hovey, of Newburyport, Mass. For instance, the real dimensions of these caves have been very much overestimated, because no accurate topographical surveys have ever been allowed by their owners, who always fear that serious investigation may result in the discovery of new entrances to the caves, and may thus deprive them of the annual benefits brought by visitors. It was recently made clear by the inquiries of Doctor Hovey, Messrs. Ellsworth Call, Le Coppey, and De la Forest[c] that the Mammoth Cave is far from possessing the 220 miles of galleries reckoned by some French books of geography, or even the 150 miles estimated by D. D. Owen (Geological Survey of Kentucky, 1856), to which the number was afterwards reduced, and that much more truly the whole extent of its known and penetrable corridors and avenues does not exceed a total length of 30 miles, still leaving Mammoth Cave the longest cave in the world.[d] Wyandotte Cave, reputed to be nearly 24 miles long, appears not to exceed 9 miles. The "bottomless pit" in this cave, formerly said to be 200 to 300 feet deep, showed only 105 feet to Hovey's measuring line.

[a] Blatchley.

[b] Celebrated American Caverns, 1882; reedited 1896.

[c] Quelques grottes des Etats-Unis d'Amérique, Spelunca, No. 35, novembre, 1903.

[d] The largest and finest cave in Europe (Adelsberg, in Austria) is only a little more than 6 miles (10 kilometers) long; second to it comes the newly discovered Höll Loch (Switzerland), with nearly 6 miles, which may prove the first European cave when the present explorations have been finished; and third, the Agtelek Cave (Hungarian), with 5½ miles (8,700 meters).

My aim in this little paper will be to suggest how useful and interesting would be a serious exploration of American caverns from the numerous and very different scientific points of view which, during twenty years only, have been so successfully disclosed in the European underground inquiries—especially since new caves are yearly discovered in America, and some so large as to promise to be larger even than Mammoth Cave; for example, the Colossal Cave of Kentucky, discovered only in 1895, or others, with stalactites and stalagmites nearly as fine as the French or Austrian, which seems not to be the case in the previously known caves in the United States.

I earnestly wish and advise that the geographical and geological societies or tourists' clubs in America may make their best efforts to have their gigantic caves carefully preserved by cave hunters in the way actually practiced in Europe by the specialists who claim the name of speleologists.

Speleology, the science of caves, is, in fact, a subdivision of physical geography, like limnology for lakes, oceanography for seas, hydrology for water. Long ago the Austrians called it Höhlenkunde, and practiced it diligently in the characteristic land of the Karst, near Trieste. especially in a new form, since 1883, by Hanke, Marinitsch, Muller. and others. After their example the French, under my own guidance. introduced the same sort of work in the limestone tablelands of northern France about the year 1888. Following those methods I have myself since that date, in all the countries of Europe, partly on my private account, partly on government appointments, explored more than a thousand abysses, caves, underground rivers, and springs, and speleological explorations are spreading now with much activity not only over France and Austria but also over the British Isles, Belgium, Spain, Italy, Greece, and Russia, bringing every year one or another new and important contribution to human knowledge.

In order to have the same progress extended to America I will venture, in a few words, to show how speleology may claim a kind of individuality as a science of itself.

Even in the earliest antiquity caves always excited human curiosity, being for centuries mere subjects of fables and fancies, now quite vanished away, at least among learned people.

As late as the year 1776 the German Doctor Esper published the first scientific cave work, relating to the large mammalian bones found in the Gailenreuth caves (Bavaria) and declaring them to be animal remains and not the bones of human giants, as was formerly believed. On the basis of these observations, Cuvier established the actual beginning of paleontology.

During more than a century afterwards exploration in caves mainly dealt with paleontological, prehistorical, and zoological questions, about which American works and papers may be quoted, such as those

of Agassiz, Lund, Owen, Cope, Shaler, Tellkampf, de Kay, Putnam, Packard, Hovey, Cox, Mercer, Miss E. A. Owen, Ellsworth Call, and Percy von Epps.

But many problems of underground geography, hydrology, meteorology, public health, and rural economy, such as the intermission and variation of springs, the real origin of caverns, abysses, freezing-caves, etc., still remained quite poorly elucidated.

It is well known that the most irregular feature of all the limestone countries is their peculiar hydrography. The large streams, hollowed out in deep canyons, have very few or no visible affluents. The rain water falling on the plateaus disappears in natural pits, named sink holes in America, swallow holes in England, avens or abimes in France, Trichter or Abgrund in Austria, aiguigeois in Belgium, katavothres in Greece, and hundreds of other local terms, changing with nearly each province in Europe. Thus absorbed by these pits and through the minor fissures and joints of calcareous rocks, the rain water percolates and circulates underground in a way which was not explained previous to 1888. By means of my descents, and the Austrian ones, into the pits, it is now understood how this water runs through the small or large caves it has excavated until it meets beds of impervious clay and forms deep water reservoirs or issues at the lower level of the valleys (canyons) in the form of springs of supposed pure and clear water, with considerable force and volume, these so-called springs of the calcareous formations being much less numerous but stronger than the small and countless springs of the crystalline or detrital formations.

It seems not to be very well known in America that a number of curious discoveries have supplied and may still supply in the future the methods of exploring natural pits—methods that form the principal chapter of practical speleology. Yet these methods (as I have been told) were employed in the discovery of Colossal Cave, Kentucky, which was explored by descending with ropes a very deep shaft. Many accounts of cave exploration may be found in my published works,[a] but I will here point out only the principal features of the matter.

In Europe these yawning pits are of all forms and sizes, round or oblong, narrow or wide: their dark lips gape suddenly upon us, in any topographical position; they were looked on but with fear, travelers and sheep frequently falling into them on moonless nights or foggy days. Local legends made them quite dreadful. Three only, to my knowledge, had been descended during the eighteenth century,

[a] Les Cévennes, 8°, 1897; Les abimes, 4°, 1894; Irlande et cavernes anglaises, 8°, 1897; La spéléologie, 8°, Paris, Carré et Naud, 1900; Padirac, 8°, Paris, Delagrave, 1901; La photographie souterraine, 8°, Paris, 1903. English papers: The land of the caverns, Appalachian, 1903; The descent of Gaping Ghyll, Alpine Journal, May, 1896; British caves and speleology, Geographical Journal, November, 1897.

but they received daylight to their very bottom, namely: Mazocha (in Moravia), in 1768, 450 feet deep; Elden Hole (England), in 1770, 250 feet; Tidoul (France), in 1785, 200 feet, and a few others previous to these last twenty years. The deepest of all, the Trebiciano pit, near Trieste, Austria, measures 1,050 feet, but is partly artificial, and was explored in 1860, 1861, by Lindner in search of drinking water for Trieste, and utilized with an engineering piece of work covering eleven months. The Austrians, since 1883, and I myself, since 1888, with my French and foreign followers, have visited hundreds of these pits, many scores of them over 600 feet, the deepest being in France—the Chourun-Martin, in the Alps. I discovered and fathomed this in 1899 to 1,000 feet, and think it probably still 500 feet deeper. We could penetrate it only to a depth of 250 feet on account of the appalling amounts of stone and snow giving way and plunging down the terrible chasm at any motion of the ropes and descending apparatus.

Of course it is no very pleasing sensation to let one's self be lowered, at the end of a rope, along a very long rope ladder, quite perpendicular, like the 535-foot chimney, in one drop, of Jean Nouveau (Vaucluse, France), or in the repeated superpositions of bottle-shaped pits in several stories, which is the general case, or just in the middle of the 300-foot subterranean waterfall of Gaping Ghyll, England, very often to find nothing else at the bottom than a well blocked with huge stones or choked with clay, except sometimes an accumulation of fatal carbonic acid gas, and always with a bombardment of pebbles detached from the sides of the shaft by the friction of the rope. But what are all these risks and difficulties when such a first descent discloses to the eyes, at the end of an "abime," a gigantic reservoir like that of Rabanel (Herault, France), 700 feet deep, or that of the above-named Gaping Ghyll, or a 4-mile avenue of first-rate geological interest, such as Bramabiau (Gard, France), or the refreshing grottoes, rivers, and lakes of Padirac, Dargilan, Aven, Armond, in France; or Nueva del Drach, in Spain, the whole gleaming gloriously under the flashing magnesium light, weird to the tourist, exciting to the explorer. It is certain that the improvement and extension of cave hunting in America shall, perhaps still better than in Europe, supply more curious and interesting discoveries, especially the methodical investigation of sinkholes and of underground rivers, such as that already known in the Mammoth Cave.

Therefore I must here mention the two main appliances necessary for these researches, which lead from time to time to the discovery of some mysterious marvel or some valuable fact of scientific importance—the portable canvas folding boat and the telephone. Curiously enough, both are American contrivances.

The boats are of different patterns, made by Osgood & Co. (in Battle Creek, Mich.), King (in Kalamazoo, Mich.), and others in America,

ı disappears to come out through the corresponding owing along the cave river; for instance, at Bramabiau Mas d'Azil (Ariège, France), and several large grottoes ıkin (Asia).

ought (and I know it is the current opinion in America, haler's and Hovey's statements) that these natural pits falling in of the surface, and that, like manholes, they rse of subterranean rivers. In reality this is not comh, for pits are rather tectonic fractures, which fierce of waters have enlarged by erosion, corrosion, and ssure. The sinking of a cave's roof is sometimes, of ɔrtant factor in the formation of pits, such as Dadere ɔr the Marble Cave, Missouri, but not a universal one. Europe, I reckon only at 10 per cent the number of lue to this cause.

ved now that, in limestone formations, the large reserrranean water form long and narrow running streams rge lake-like expanses; the whole matter of undertion being in part ruled and directed by the preexisttonic fissures of the earth's crust.

most important results of the scientific exploration of to the preservation of public health. I first obtained nat a supposed pure spring stood in direct connection ink hole in which peasants had been accustomed to throw nimals, as in a dung hole. Such a mischievous practice ison the fountains by the decay of carcasses. It was ıt the limestone springs are not true springs, but almost ences—that is, new coming forth of rain waters or viously buried in the ground (through the natural hole), s of dangerous impurities. This most serious point of ıtly led in France to a special important law (la loi sur ique du 15 fevrier 1902) which forbids throwing dead ubbish into the pits and prescribes very rigid precautions ıl and private obtainment of drinking water.

health also the investigation and disobstruction of pits ıoles procured in Austria (by Messrs. Putick and Hrooky) e (by M. Siderides and myself) has been accompanied by ogress in the draining of nasty swamps and the suppres- fields.

ists wish to know the exact place, capacity, and condiunderground reservoirs which feed the springs and the annels of limestone countries. By improving these resersupplies of water can be obtained, and floods as well as ay be in some places avoided. For this purpose the ...nment, according to M. Kraus's advice, ordered, as

early as 1886, a series of explorations and improvements in the Karst and Bosnien Herzegovina caves, which are still carefully pursued by the engineers—Pulick, Hrooky, Riedal, Belliff, and other. For similar objects I was called in the year 1903 to the western Caucasus by the Russian government. Moreover, engineers are interested in the subject in order to learn of all the caves or water courses which might interfere with the building of roads, railways, or tunnels, as they often have seriously interfered in France and Austria, and lately in Switzerland, with the great Simplon tunnel.

The meteorology of caves has also brought new results, proving that their temperature (and even that of springs) is not unchangeable, as has been long believed, but extremely variable, ranging from below 0° up to 3.8° Cel., varying even in different spots of one cave; and that in vertical pits the temperature does not increase with the depth, as in mine shafts, because the numerous crevices in the limestone allow the superficial air to circulate freely in the interior of the calcareous rocks.

In order that this paper may be read and prove useful, I purposely make it short; and for all other particulars concerning the special aims and desired extension of scientific cave hunting I will only refer to the publications of the French Société de Spéléologie, founded by myself, at Paris,[a] ten years ago, to collect all the remarks and notices that were formerly scattered among various periodicals. The sixty papers already issued by this society under the name of *Spelunca* (a review of speleology) show plainly that it deals with something more than a mere sport, not only with the matters considered above, but also with the older sciences, paleontology, prehistory, and zoology.

Out of the information sent to *Spelunca* by its American fellows I will note a few of the problems yet to be resolved in American caves:

Good topographical plans are needed of Mammoth Cave and all other American caverns.

Thorough exploration and knowledge is desired of the new caves of Kentucky around Mammoth, with which they may be connected and form a gigantic union extending for hundreds of miles, viz, Colossal, Salts, Nectar, Grand Avenue, White, Dixon, Long, and Short caves.

In Schoharie and Albany counties (New York) there are said to be limestone plateaus with unknown sink holes and underground rivers, whose underground floods spout from those rocks in the same way as the turloughs or blind lakes of Ireland.

It would be interesting to know if Wind Cave in South Dakota possesses, as has been stated, 2,500 rooms, 97 miles of avenues, and a depth over 1,000 feet, and if it is really an old extinct geyser, as was suggested to Miss L. A. Owen.[b]

[a] Paris, 34, rue de Lille; fee for membership, $3 a year; apply for information to the treasurer, M. Lucien Briet, in Charly (Aisne), France.

[b] Cave regions of the Ozarks and Black Hills, 1898.

Crystal cave in South Dakota boasts of an uncertain length, ranging from 16 to 36 miles.

Sink holes 300 feet deep are reported in Hahatonka (Ozark region of Missouri); also a lava cave, named Spencer's cave, with rooms over 300 feet long, in Skamania County, Washington.

The sea caves of Santa Barbara, near Los Angeles, southern California, are said to be very extensive, and a hot underground lake (76° Cel.) has been reported near Boise City, Idaho.

Mexico and Central and South America might furnish a much larger list of American caves which deserve to be scientifically explored.

I hope it will be deemed a duty of this congress to recommend that the United States Geological Survey and the American geographical associations may not limit their hydrologic research to artesian waters and well prospects, but that, like those in Europe and probably to a still higher degree, the huge American caves may become for them objects of accurate and thorough investigation.

THE VALLEYS AND LAKES OF THE ALPS

By ALBRECHT PENCK, Vienna, Austria

The study of river action has been very much advanced in the Alps, whose torrents give magnificent examples of the destructive and constructive action of running water. But the surface features of the great European mountain chain do not at all correspond to those we might expect after a careful study of river action. Rivers seek to establish a normal curve, which grows continually gentler downstream. The greater valleys of the Alps, however, do not show so regular a grade. At the headwaters their floors present many irregularities; gentle grades alternate with steep ones. Instead of a slope curve there is a succession of descending steps. Farther down we find for several miles a valley floor, sloping normally, which has been graded by the river. This floor in some cases ends in a lake basin, where the normal slope is changed into a reversed one. Most of these features are not produced by river action, but rather are destroyed by it. Indeed, we see how the rivers intrench themselves in the steep parts of the stair slopes, and how they fill up the lake, which generally occupy the lower part of their valleys in the Alps. Their action is directed toward removing the irregularities of their courses.

There is still one other important particular in which the slope of Alpine valleys does not obey those rules which control normal valleys. The law of Playfair is not applicable to them.. The mouths of the lateral valleys are not usually accordant. They do not lie at the level of the floor of the main valley, but lie at a higher level. Their rivers often tumble down in waterfalls to join the master river, or they have cut into the floor of the lateral valleys a deep gorge, through which they swirl and rush to reach the bottom of the main valley. These are the very well known "Klammen" of the eastern Alps and the gorges of the western Alps, and many waterfalls of this mountain chain lie at the mouths of side valleys.

The cross sections of our Alpine valleys are also other than what one might expect. The master valleys have in general an extended flat bottom, at the sides of which rise very steep walls. At a certain height these steep slopes change into more gentle ones, and a very well-

marked ledge separates the two slopes, which forms distinct shoulders on both sides of the valley—a condition not found elsewhere. That part of the valley which lies below the shoulders has often a trough-like appearance. The trough extends upward to that region in which the flat, aggraded valley bottom is succeeded by a series of rocky steps, and here is often formed a very striking trough's end by the cliff side of a high step. Above the shoulders the valley slopes are far from being regular; often they form cirque-like niches, at the bottom of which little tarns occur. These are the "Kare" of the Alps, the corries of Scotland.

There are certain rules which control the occurrence of all these features. The heights at which the side valleys terminate above the main valley show a very regular arrangement. They describe a curve, which slopes down regularly between the height above the trough's end and that point where we meet with the last part of the reversed slope of the valley floor. The shoulders show a similar but less regular arrangement. They are also limited by the trough's end and the end of the last reversed slope of the valley floor. Their height also decreases, though not regularly, between these two points. The whole arrangement leads to the conclusion that the trough has been excavated in an older valley that had a higher floor; the shoulders are at the intersection of the trough sides and the side slopes of the old valley. The hanging side valleys are parts of the old valley system which suffered little from erosion and preserved their original depth. This conclusion is now generally accepted, since the connection of all these phenomena has been recognized, but the conclusion is not in harmony with ideas which prevailed for a considerable period, when only one part of the irregularities of Alpine valleys was taken into consideration.

For some time the great Alpine lakes have been regarded as the only irregularities of the Alpine valleys, and the questions of Alpine geomorphology have included only the formation of the great Alpine lakes. Of the different ways in which valley lakes are formed only two have been considered, namely, the hypothesis of warping and the hypothesis of glacial erosion presented by A. C. Ramsay. In order to understand the former, let us assume that the lower part of a normal river slope was elevated or that the upper part was depressed. The normal slope curve would then be changed into a curve with an ascending part having a reversed slope, and the part limited downstream by this reversed slope would be filled with water, or submerged. This idea, at first suggested by Sir Charles Lyell and later developed further by Rütimeyer and Heim in Switzerland, helps us to understand the transformation of some valleys into lake basins; but it leads to consequences which are not supported by observations in the field. Earth movements which could reverse the slope curve of a master river must

then agai its branches, and if a part of its curve is depressed to form a mouton affluents of this part must also be depressed, and their lower directiomust be submerged in a manner similar to the basin formed in the depression of the floor of the master valley. Lakes formed by It cabsidence of part of a river valley must digitate into the side origi's. Contrary to this, the side valleys of the great Alpine lakes are frombmerged at all; they are hanging above the lakes and their floors can no traces of depression. The digitations we find now and then the lpine lakes have nothing to do with the submerging of true lateral freys; they do not stretch toward the mountains from which the side ileys come, but extend in the opposite direction. They are related the frequent valley bifurcations which will be considered later.

The basins of the great Alpine lakes occupy only a part of the troughs of the Alpine valleys, and every hypothesis as to their formation must deal with the trough. The trough bears every evidence of being eroded in a former river basin, the side branches of which suffered less lowering than the main branch. This fact is now generally admitted by all who have studied the relations between the high-hanging valleys and the main valley, and it is generally acknowledged that the latter, in comparison with the former, has been overdeepened by erosive action. But there is still a diversity of opinion as to this action. Some authors—Kilian, Garwood, and Frech—believe that it has been exercised by rivers, while the hanging valleys were occupied by glaciers and protected by them against the erosive action of water.

This idea ascribes to river action results such as are usually not accomplished by it. The trough does not bear the features of a common river valley; it has the width which river valleys attain in their maturity, but it has not the normal grade which rivers always have in this phase of their development. Their side slopes have the steepness of youth, as is proved by innumerable landslides occurring along them. It is a peculiar mixture of young and old valley forms we find in our large Alpine trough-like valleys, a mixture which can not be understood by the assumption of normal river action, and no attempt has been made until recently to show how this mixture was formed by rivers. As to the hanging valleys, however, there are some cases in which they were not occupied by glaciers; therefore, the protection of their bottoms by glaciers can not have caused the elevation of these bottoms above those of the main valleys. The hanging valley is not a feature characteristic of glaciated regions; only hanging mouths are confined to such regions.

He who wishes to examine the Alpine valleys in the light of river work must not first take the valley floors into consideration; he must observe the river beds. There the law of Playfair has no application. Where in the state of their maturity the surfaces of two rivers unite

at the same level their bottoms will not do so. The bottom of a larger deeper stream generally lies deeper than that of its smaller and shallower affluent. The bottoms of side river channels are high hanging above those of the main rivers. We here have steps at the mouths as in the Alpine valleys. While the surfaces of rivers grade down continually their bottoms show irregularities which resemble those of the floors of some Alpine valleys. The forms of mature valleys are determined by the laws which control the *surfaces* of moving liquids, while the forms of the Alpine valleys are governed by the rules controlling the formation of the *floors* of moving liquids; instead of the law of Playfair the law of adjusted cross sections comes into action.

There can be no doubt what particular moving liquid or quasi-liquid is related to the features of Alpine valleys, since it has long been known that all the greater Alpine lakes lie in the region of the old glaciation, and later researches have proved this for all the special features of Alpine valleys. The overdeepening, with all its accompanying features—the trough, the trough's end, and the lake lying in it, with its shoulders and the hanging mouths of side valleys—is confined to the area glaciated during the great Ice age, and the moment you leave this area you reach the normal features of mature valleys, with accordant mouths of side streams; you reach mountains whose summits are not dissected by corries. The concurrence of Alpine valley troughs and old glaciers suggests the theory of origin by glacial erosion. The theory of glacial erosion was advanced by A. C. Ramsay for the formation of Alpine lakes. We go a great deal further than he when applying that theory to the formation of the far more extended feature of the troughs in the Alpine valleys, for the lake basins occupy only those parts of the troughs that extend below the lowest part of their circumferences.

The erosive action of glaciers has very often been denied and is even now denied by some, while it has been at various times vigorously supported. This diversity of opinion is caused by the fact that we can not observe how glaciers act upon their bottoms, their work being concealed by their icy mass. We usually see only how the glaciers transport moraines and deposit them about their lower ends. The fact that stone avalanches not rarely fall down from the side walls of a valley on the surface of a glacier suggested the idea that the material of the surface moraines is due entirely to the action of weathering exercised on those cliffs which overlook the glacier. The study of the moraines on actual glaciers, however, has revealed more clearly the fact that they can not be entirely derived from those cliffs, but that they come in large part from the bottom of the glacier. What effects are here produced by the glacier can be observed only at those places which have been covered by the ice for some time and

then again revealed. Here we observe those very well-known roches moutonnées, polished and striated surfaces which dip gently in the direction from which the glacier came but which abruptly terminate in the opposite direction. In general, rock is here limited by joints. It can not be longer maintained that we have at those places the original surface of the rock before us; we stand rather before a quarry from which rock fragments are broken out and plucked away. This can be proved now and then by observation. At the Horn glacier, in the Zillerthal Mountains, for example, I found near a roche moutonnée fragments which had been plucked out from it and transported by the ice for some distance, slightly upward. They fitted perfectly into the quarry from which they had been taken. Thus roches moutonnées teach us that glaciers do not exercise a scouring action alone on their beds, as is generally stated, but that they also effect a quarrying and plucking action, which is not generally known. Therefore, the two sides of a roche moutonnée should no longer be called "push side" and "lee side," but rather "scour side" and "pluck side," terms introduced by Shaler. Plucking forms the most important part of glacial erosion; it is exercised on the bottom as well as on the sides of its bed, and since the glacier can also transport fragments upward it is enabled to adjust its bed to its mass and its movement.

The adjustment of bed to mass and movements is not confined to glaciers; the same adjustment occurs in rivers. The difference lies partly in the fact that the glaciers' beds are, on account of the slowness of glacier movement, far more conspicuous than the beds of rivers of equal capacity. The adjustment indicated is controlled by the necessity that past a given cross section of a river or of a glacier must annually move the whole quantity of run-off or of ice produced in the corresponding catchment basin. There is, therefore, a relation between the size of cross sections, Q, and the mean velocities, V, of the fluids on the one hand, and of area, A, precipitation, p, and evaporation or ablation, e, on the other, which can be expressed by the following equation:

$$V\,Q = A\,(p-e)$$

If there are no sudden changes either in the velocity of the moving bodies—those changes will always disappear in the course of time—or in the precipitation and evaporation or ablation of a certain region, then neighboring cross sections will increase in the same way as the areas do. They will be nearly equal in size if there is only a slight increase of the catchment basins between the two sections. They can be rather different if a sudden increase of the catchment basin occurs. If, for example, a river or glacier gets an important affluent there will be a rapid increase in the size of the cross sections.

The arrangement of neighboring cross sections is controlled by the fact that the surface of the moving liquid must have a slope. Their surfaces must continually decrease in height in the direction of the movement, and where two moving fluids unite their surfaces must join at the same level. The surfaces of glaciers as well as the surfaces of rivers obey the law of Playfair, but their channels at the same time conform to the law of cross sections. The large cross sections of a main river or a main glacier, as well as the smaller cross sections of their affluents, have accordant surface junction, and therefore their bottoms must have different heights as long as the cross sections are similar to each other, which is in general the case. The bottoms of side streams hang above the bottom of the main river in the same way that the bottoms of side glaciers hang above the bottom of the main glacier. The hanging mouth is a feature of the bottom of moving liquids, the accordance a feature of their surfaces. Since the river surfaces are the base levels of the country along their sides they govern the heights of the bottoms of the valleys, which obey, therefore, the law of Playfair.

Every river bed shows inequalities, which may be compared with the inequalities of the glacier bed. There is, however, one very marked difference. Most rivers constantly grow, and their cross sections become, therefore, larger and larger. Most glaciers, however, grow only to a certain limit; then they decrease by ablation until they terminate. Therefore their cross sections will increase at first and then decrease. In a simple glacier the maximum cross section will be found just at the snow line; in a composite one it may occur farther down. Above and below this maximum cross section the surfaces and bottoms of the cross sections will approach one another until they finally coalesce. While, however, the surfaces must be arranged in descending order, this is not the case with the bottoms. It is shown by observation that glaciers can also move on reversed slopes as long as they have a sufficient surface slope—that is, as long as the surface slope is considerably greater than the reversed bottom slope. To keep up glacial movements it is necessary that the centers of successive cross sections be arranged in descending order. If we have, therefore, at the lower end of a glacier a series of cross sections of diminishing size, their bottoms may rise if their surfaces slope so steeply that their centers of gravity form a continually descending line. Therefore we find in the bottoms of glaciated valleys reversed slopes, and we must expect to find them chiefly near the ends of the old glaciers. Here, indeed, the most of the larger lakes of the Alps are found.

The general arrangement of the Alpine glaciation during the great Ice age was the following: The interior valleys of the mountain chains were filled up with an enormous, flat cake of ice of 2,000–2,500 meters

elevation, interrupted by the highest ridges, from which deep affluents poured into the vast mer de glace. Its surface sloped down in its center very gently and with increasing steepness toward its rim. Under this steep marginal slope lie the existing and former lake basins of the Alps, and the location of their reversed slopes indicates the region where the glaciers' erosive action gradually ceased. It has long been recognized that the depth of these lakes is far greater in the south than in the north, but no adequate explanation has been given. This phenomenon is consistent with the fact that the marginal slope of Alpine glaciation on the south side of the mountains was twice or thrice as steep as on the north side; here a far greater reversed slope could be overcome by the glaciers. It must be borne in mind, however, that thick morainic deposits occur at the lower end of the trough. The lake basins of the Alps are, therefore, not formed by glacial erosion alone, they are partially dammed up by the thick moraines and thick gravel deposits which the glaciers accumulated at their ends, and this accumulation assumes on the south side of the Alps a far greater thickness than on the north side, because it is concentrated over a less extended area. This damming up raises the levels of the Italian lakes far higher than those of the south German lakes, and the difference in the depths of those lakes is partly caused by this difference of accumulation.

The rule of the cross sections helps us to understand not only the formation of the lake basins in Alpine valleys, but to understand how the trough's upper end was formed. We usually find it where there was a strong confluence of the glaciers in the upper parts of a valley, where the slope glaciers united to form the valley glaciers. The mass of ice coming from this semicircular head was pressed here into the diameter of the same circle. Now, in order to maintain a continuous movement, an increase of velocity was necessary at this place. This increased velocity must act on the bed of the glaciers until a sufficient depth is gained. Theoretically, this depth must be 57 per cent (that is $\frac{\pi}{2} - 1$) greater than at the semicircle from which the glaciers came.

The cross sections of glacier beds are in general, as was long ago recognized, U-shaped, which indicates that a certain relation between width and depth is the most appropriate one for the glacier's movement. This U form is, however, constant only in homogeneous rocks; in places where there are sudden changes in the nature of rocks, we find changes in the shape of the trough. At those places we observe that the glaciers exercise a strong selective erosion on their bottoms; some rocks resisted more than others, and here the glacier bed shows a remarkable adjustment to the nature of the rocks. Many steps in glaciated valleys are caused by highly resistant rocks; now and then, but not at all regularly, an increase of width corresponds here to

a decrease of depth of the glaciated valley. Conversely, a sudden increase of width in a glaciated valley is often connected with a diminution in the depth of the trough.

The study of the old glaciers of the Alps reveals that, as far as their movement is concerned, they consist of two parts. In their upper parts, where they were fed by numerous affluents, there was a confluence of ice in the main valleys corresponding to the confluence of waters which occurs there now. In their lower parts, however, they no longer received lateral affluents. Here they spread out fan-like on the plains at the foot of the mountain chain or even in its interior, penetrating into those valleys which afforded them no affluents. Regions of glacial confluence and glacial diffluence are sharply separated from one another. They have nothing to do with the feeding and melting part of the glacier and are determined only by the presence or absence of lateral affluents. The confluence and diffluence of a glacier, therefore, may occur as well in its névé region as in its region of ablation—in its feeding or in its dissipating (after H. F. Reid) part—but generally the confluence prevails in its upper parts and the diffluence in its lower parts. On the north side of the Alps the diffluence is excellently represented by the enormous ice fans in the German Alpenvorland, which were formed by the glaciers of the Rhine, the Tsar, the Inn, and the Salzach, while in Switzerland the diffluence was hindered by the Jura Mountains, so that no regular fans were formed. On the south side the fan-like diffluence of the ice occurred partly in the Alps and was nearly restricted to it in the region of the lakes north of Milan, which we will call the Insubrian lakes, after the ancient country of the Insubrii, whose capital was Milan.

At every place where a fan-like diffluence of the ice occurred its bed shows ramifications which have a spoke-like arrangement and slope toward their center—as, for example, in the fan of the old Rhine glacier. Lake Constance is the center of the fan; its western termination bifurcates into the lakes of Ueberlingen and Zell. In two similar broad furrows the rivers Schussen and Argen approach the lake from the north and northeast. Lake Constance is the palm of the hand; its western branches and the furrows of the Schussen and Argen are fingers which stretch out to the rim of the old glacier. A similar arrangement is found in the fans of the old glaciers of the Inn and the Salzach; the troughs of their valleys terminate by branching in the sub-Alpine plains; every branch is followed by a river flowing toward the Alps, in the direction from which the ice came, thus marking the reversed slope of the bottom of the different branches of the ice which formed the ice-fan. The same features recur where the diffluence of the glacier took place in the mountains. Lake Como bifurcates, and the Como branch has no outlet; its waters must first flow toward the Alps to reach the outlet at Lecco. On the east side

of Lake Como a branch of the old Adda Glacier penetrated into the Valsassina, whose waters flow toward the Alps in order to reach Lake Como, revealing a reversed slope. A fourth finger of the Adda Glacier passed over the pass of Porlezza and reached the eastern deep part of Lake Lugano, which drains into Lake Maggiore. If the morainic deposits south of the eastern part of Lake Lugano were higher, that lake would discharge into Lake Como, and the relation of the eastern part of the lake of Lugano to Lake Como would become very clear. It also is a finger lake, lying around the palm of Lake Como, but separated from it by a low pass.

The finger lakes and finger valleys, with their reversed drainage, form a very conspicuous feature in the regions of glacial diffluence. Many phenomena indicate that they were not originally there and that their formation was connected with the diffluence of glaciers. Lake Orta is a typical finger lake in the region of diffluence of the old glacier of the Ticino and has a reversed drainage. It occupies, however, a valley whose catchment basin has a peculiar arrangement, as if it would be drained toward the Po plain. It can be shown that the Lecco branch of Lake Como came very lately into use as an outlet for a branch of the Adda Glacier. It can be further determined that the different fingers in the large fans of the glaciers of the north side of the Alps are younger than the gravels of the first Glacial epoch. How glacial diffluence controls the formation of these features can be shown by the study of those forms that are originated by it.

When a glacier fills a valley above the height of the notches in its watershed it flows over these notches if it is not hindered by ice masses on the other side of the pass. By overflowing it exercises on the pass a conspicuous erosive action, by which the pass is lowered and widened. This can be seen on all passes which have been everflowed by ice. On the St. Gotthard and on the Grimsel ice marks are very clear; roches moutonnées with scour and pluck sides spread over the culminating surface, and little mountain tarns indicate that the glacier eroded flat basins. The longer the ice action goes on the more the pass is lowered; the height of the watershed is leveled down to the floor of the valley, into which the glacier pours, and a vast flat is formed which begins at the shoulders of valleys from which the ice branched. Many Alpine passes belong to this type; they can be reached from the glacier valley only by a sharp ascent on its trough slope, while the descent into the neighboring valley is very slow. This is the case with the Monte Ceneri, which opens in the left side of the valley of the Ticino and allows one to enter the neighborhood of Lugano from the north; also with the Pass of Seefeld, through which one may reach the valley of the Inn, south of Munich, and with the Brüing Pass in Switzerland, as well as with the Pass of Reschenscheideck, through which one goes from the lower Engadine to the

headwaters of the Adige. The erosion of this pass was carried so far that the floor of the pass reaches the shoulder of the Engadine, and that some old affluents of the Inn were already diverted into the Adige. A further state of erosion of an old pass is shown by the situation of Lake Orta. Here the pass has been totally leveled down, and considerable accumulations of moraines south of it force its water northward toward the Alps. Finally, in Valsassina, the long, reversed slope is independent of the terminal moraines south of it; it is a branch of the trough of the Adda Valley, which extends here into a side valley, where it terminates obtusely. This series of different stages shows us how a pass can be removed by glacial erosion and how the watersheds can be moved to the outer rim of the old glaciation. This state, however, has not been reached everywhere; its establishment depends not only on the intensity of glacial action but also upon the original features.

A pass originally very high will stand far longer than a low one. This fact must be observed in those cases where the valley reached by a branch of the ice is overdeepened in the same way as is the main valley. Thus, for example, the arm which branched off the glacier of the Ticino Valley at Monte Ceneri overdeepened the valleys west of Lugano, which are now occupied by the west branch of Lake Lugano; and the arm of the Adda Glacier which branched off at Menaggio and passed the saddle of Porlezza has overdeepened the valley of Porlezza and transformed it into the lake basin of Porlezza, which is the deepest part of Lake Lugano. He who considers only the lake basins as the results of glacial erosion will be much puzzled by the interruption of the erosive action of a glacier by a pass. On the other hand, he who follows the whole development of glacial erosion will easily recognize its great effect also on the pass traversed by the ice, and he will perhaps be aware that the erosion on the pass itself was far greater than that farther down, where a smaller degree of erosion was sufficient to form a basin.

The diffluence of the ice is controlled by the rules of cross sections, as is the confluence. In the same way that steps were formed at the places where glaciers met, other steps were formed where branching occurred, for here there was a sudden diminution of the ice. There are steps of confluence in the region of confluence, and steps of diffluence in the region of diffluence. The steps of confluence are seen in the hanging mouths of side valleys; the steps of diffluence are hanging openings of those valleys which were entered by a branch of the ice. The height of both kinds of steps will generally be the more considerable the greater the difference between the main glacier and its affluent or diverting branch. Thus the step of diffluence of Valsassina east of Lake Como is higher than that of Porlezza west of this lake, and the branches of Como and Lecco divided at the same level, since they were of nearly equal size. Here is a true bifur-

cation of branches, and a bifurcation of valleys follows the diffluence of the ice. The openings of the neighboring valleys reached by the ice are so deeply eroded that they will be easily buried by the accumulation of river material which is going on in all overdeepened valleys since they have been vacated by the ice. The bifurcation of the Rhine Valley near Sargans, that of the Isère Valley at Montmélian, and that of the Salzach Valley near Zell-am-See, are fine samples of valley bifurcation caused by glacial diffluence and not, as has been often said, by capturing.

The establishment of a reversed drainage in consequence of glacial diffluence is very much helped by the accumulation of moraines. They surround the dissipating part of the glacier. They follow its order as lateral moraines and surround its end as frontal moraines. In the glacier fans north of the Alps they form conspicuous landscapes; they are often watersheds between the reversed drainage of the fan and the drainage of its surroundings, which corresponds to the drainage of the ice fan during its existence. Thus, for example, the terminal moraines of the Rhine Glacier form a part of the great European watershed between the northern seas and the Mediterranean. On the south side of the Alps the terminal moraines are still more conspicuous and form amphitheaters around the ends of the overdeepened glacier beds. These are the so-called morainic amphitheaters of upper Italy, whose deposits partially dam up the Italian lakes. Those glaciers which ended in the Alps left their terminal moraines in the valleys, where they separated the reversed drainage in the region of diffluence from a peripheral drainage. The latter has been partially formed by shoving away the original rivers which descended to the ground before it was entered by the glaciers. When the ice came they could not continue their old courses and must flow along its rim. Thus they were pushed from their old courses and driven into new ones, which surround the ends of the glaciers. Many of those shoved river courses are no longer in use; they are often captured by the headwaters of the reversed drainage, as, for example, the Mangfall in Bavaria, which for a long distance flows along the terminal moraines of the Inn Glacier, until it makes an elbow at the place where it was captured by a stream flowing on a reversed slope. Other shoved river courses became stable, hence they were driven into the valleys of other rivers. Thus north of the old glacier of the Drau the waters of the upper valley of the Gurk were shoved by the rim of the ice into that valley which is now that of the middle Gurk, and which formerly had its own river. Here the moraine of the glacier along which the Gurk was shoved is still visible. In other cases the moraines are insignificant, and the course of shoved rivers, especially where the glacier ended in a deep valley, can be traced only by the erosive action exercised along the glacier, which cut gorges into the projecting parts of

the valley slope. A magnificent example of such a shoved river can be followed on the left slope of the valley of the Sesia in upper Italy, below Varallo. By their erosion on mountain passes, by establishing reversed slopes in their terminal regions, by shoving the rivers coming from nonglaciated regions, the old glaciers of the Alps have profoundly modified, especially near their ends, the pre-Glacial hydrography of the Alps.

DISCUSSION

Dr. J. W. Spencer: Professor Penck's comparison of the German with the Italian lakes seems hardly applicable, as the latter were backed by high glaciated mountains that sent glacial tongues down the valleys instead of by a low continental glacier obliquely overflowing the region; but the idea that the excavation of the Italian lake basins was accomplished principally by glaciers is at best only a working hypothesis, discredited by many Alpine geologists.

THE CLASSIFICATION OF MOUNTAINS

By WILLIAM NORTH RICE, Middletown, Conn.

In a famous classification of fishes proposed by Louis Agassiz, the typical bony fishes were divided into the two groups of cycloids and ctenoids, according to the character of the scales. When it was discovered that oftentimes the same fish has both kinds of scales, the classification became somewhat discredited. It was good as a classification of scales, but not good as a classification of fishes. It seems to me that most of our classifications of mountains are open to a somewhat similar objection. The same mountain must belong to two or more different groups. For instance, James Geikie divides mountains into the three groups: Mountains of accumulation, mountains of elevation, and mountains of circumdenudation.[a] The second group, of course, includes folded mountain ranges; but it is needless to say that, except in the very youngest of these ranges, the extant ridges and peaks might with equal propriety be called mountains of circumdenudation. The volcanic cones perched on the crest of the range of the Andes owe their elevation in part to accumulation of volcanic material and in part to crustal movement, and belong, therefore, both to the first and the second group in this classification. Essentially similar to the classification of James Geikie is that of Credner, who divides mountains into Erosionsgebirge, Vulkangebirge, and tektonische Gebirge.[b] Credner proceeds to subdivide the third group into Bruchgebirge and Faltengebirge. But folds and faults are so intimately associated that the same mountain is very likely to partake of the characters of both groups. Whether the Uinta Range belongs to the category of Bruchgebirge or Faltengebirge apparently depends on the particular section through the range which may be under consideration. Similar, again, is the classification given by Sir Archibald Geikie, in which he recognizes four groups: Volcanic mountains, outlier mountains, denudation ridges, and tectonic mountains.[c] Some-

[a] Fragments of Earth Lore, p. 44.
[b] Elemente der Geologie, seventh ed., p. 173.
[c] Text-book of Geology, fourth ed., p. 50.

what more elaborate, but no more free from the defect which has been pointed out in the others, is that of Upham, who makes six classes: Folded, arched, domed, tilted, erupted, and eroded mountains.[a]

The question is naturally suggested whether a satisfactory classification of mountains is attainable. Since the present form of the great majority of mountain masses and of mountain peaks is the result of a complex series of hypogene and epigene actions, I am inclined to suspect that any classification of mountains which can be proposed will either fail to afford clearly definable and mutually exclusive groups or will be itself so complex as to be cumbersome and useless.

It is practicable, however, to give a logical classification of the processes involved in mountain making, and I believe such an analysis may be useful, at least pedagogically. With reference to such an analysis of mountain-making processes, any particular mountain mass or mountain peak can be formulated, so to speak, by pointing out the particular processes which have acted in its history, and the periods of geological time in which, respectively, their action has taken place.[b] The purpose, accordingly, of this paper is to offer to the criticism of my fellow-students, and especially of my fellow-teachers, an analysis of mountain-making processes.

The characteristic of a mountain is its altitude. But mountain altitude may be reckoned (I) above the normal spheroidal surface of the earth, or, what amounts practically to about the same thing, above sea level; mountain altitude may be reckoned (II) above the immediately circumjacent area. The former conception is in general that of the mountain range or mass; the latter is in general that of the mountain ridge or peak.

(I) Elevation above the sea level may be caused (1) by deposit of material by epigene agencies (Aufschüttungsgebirge of Von Richthofen);[c] (2) by ascent of lava; (3) by crustal movement.

(1) Of elevations caused by accumulations of epigene origin the most noticeable are dunes (which sometimes attain an altitude of hundreds of feet), and glacial accumulations, as moraines and drumlins. Coral reefs, though formed primarily below sea level, may be lifted by epeirogenic movement above sea level, and may then constitute mountains whose altitude is due in part to organic deposition.

(2) Ascending lava (a) may reach the surface, or (b) it may be stopped at a greater or less distance below the surface.

(a) When the lava reaches the surface, we have the various types

[a] Appalachia, Vol. VI, p. 182.

[b] For instance, Kittatinny Mountain may be thus formulated as the result of (1) a crushing of a geosyncline into alternating anticlines and synclines in post-Carboniferous time; (2) a Mesozoic cycle of erosion, in which the region was reduced to a peneplain; (3) a broad and gentle (geanticlinal) elevation in early Tertiary time; (4) a Tertiary cycle of erosion, in which ridges were developed following the outcrops of the strong Medina sandstone. It is at best a half truth to call the mountain a tectonic mountain, a folded mountain, or a mountain of circumdenudation.

[c] Führer für Forschungsreisende, p. 678.

of volcanic structures. Here belong, besides ordinary volcanic cones, the domes formed by the extrusion of extremely viscous acidic lavas, and the broad lava plateaus formed commonly by the outflow of highly liquid basic lavas.

(b) When the lava fails to reach the surface, but intrudes itself among the strata, it may form sills, thus elevating the superjacent rocks for large areas to a limited vertical extent; or it may lift the superjacent strata into the dome-shaped elevations known as laccoliths or bysmaliths, according as the strata yield chiefly by stretching and flexure or by faulting.

(3) Crustal movements which produce elevation above the sea level are of various kinds.

(a) Mountain regions share in the epirogenic movements by which the continents are differentiated from the ocean basins. The elevation of the continental areas en masse is most probably isostatic, having its cause in the greater contraction of the suboceanic material than of the subcontinental material. The altitude of all mountain masses must be due in part to this comprehensive cause; and in the case of some hills of circumdenudation, of low altitude, but occasionally dignified by the name of mountains, the elevation may be chiefly or entirely due to this cause.

(b) But the elevation of most mountain ranges is doubtless chiefly due to those wrinklings of the crust which result from the internal contraction of the earth, to which most appropriately the name of orogenic movements has been generally applied. While there may be difference of opinion as to whether the contraction of the interior of the earth is due chiefly to the cooling of a primitively incandescent globe, or to the gravitational readjustment of a heterogeneous mass of meteorites, or to other causes, known or unknown, there is a general consensus that most mountain ranges are due to a tangential pressure in the crust, resulting from a contraction of the interior. The crust wrinkles may be, as pointed out by Dana, (α) geanticlines, or (β), geosynclines.[a] These result in two different types of mountain elevation, called by Dana, respectively, the anticlinorium and the synclinorium.[b] These terms are etymologically appropriate in the sense in which Dana used them, and it is greatly to be regretted that a number of recent writers have used them in an entirely different sense, and a sense in which they have no etymological appropriateness.[c]

(α) In the anticlinorium the mountain elevation is produced by a broad and gentle upward arching of a portion of the earth's crust. Of this nature seems to have been the elevation of the Appalachian region in Tertiary time, whereby a region that had been complexly

[a] On some results of the earth's contraction from cooling, in Am. Jour. Sci., series 3, Vol. V., pp. 423–443.

[b] Op. cit., p. 432.

[c] Am. Jour. Sci., series 4, Vol. II, p. 168

folded in post-Carboniferous time, but reduced in most parts nearly to a peneplain in Mesozoic time, gained anew a considerable altitude. This type of folding, complicated with gravitational faulting, is probably the best interpretation of the Tertiary history of the Great Basi[illegible] and some other parts of the Cordillera. Substantially this view of t[illegible] origin of the Basin Ranges is suggested by Russell in the followi[illegible] words: "If the elevation of the Cordillera system as a whole is [illegible] result of tangential strain, may we not consider the force as actin[illegible] the borders of the Great Basin, while the interior region subside[illegible] was fractured pari passu as the rim was elevated?"[a] In like m[illegible] Suess suggests as a possible explanation of the structure of the [illegible] region: "Die Vorstellung von einer durch tangentialen Dru[illegible] beigeführten Wölbung von grosser Amplitude,"[b] rightly, as[illegible] to me, affirming "that no power whatever is known which is [illegible] tically to upheave numerous large and small mountain masse[illegible] and bounded by smooth surfaces, and to maintain them pe[illegible] in this position in opposition to gravitation."[c] The hyp[illegible] broad geanticline produced by tangential pressure seem[illegible] probable than Le Conte's suggestion that the whole region [illegible] probably by intumescent lavas into an arch,"[d] forming a [illegible] whose colossal size no parallel is known.[e] The hypothesi[illegible] sideration, though incapable of conclusive verification i[illegible] state of our knowledge, seems worthy of provisional acc[illegible] only intelligible and fairly plausible hypothesis to accou[illegible] nomena of many mountain regions in which the strata [illegible] or in which the movement which elevated the present r[illegible] independent of the folds.

(β) Doubtless the most common, and what may b[illegible] typical, process in the formation of a mountain ra[illegible] progressive formation of a geosyncline followed b[illegible] the thick mass of sediments. In the crushing of [illegible] we may have as a result the alternating anticlines a[illegible] Appalachian and Jura, or the more complex foldin[illegible] of the Alps. Again, this type of folding is ofte[illegible] thrust faulting on an enormous scale, the associati[illegible] with synclinoria being as characteristic as that of g[illegible] with anticlinoria.

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[a] Geological reconnaissance in southern Oregon: Fourth An[illegible]

[b] Antlitz der Erde, Vol. II, p. 741.

[c] Dass durchaus keine Kraft bekannt ist, welche im [illegible] Gebirgsstöcke einzeln und zwischen glatten Flächen vertikal [illegible] Schwerkraft dauernd in diese Stellung festzuhalten.

[d] Elements of Geology, fourth ed., p. 277.

[e] While Dana clearly formulated and defined the [illegible] appreciated the importance of this type of [illegible] of Geology he defines synclinorium (p. [illegible] the word anticlinorium, though [illegible] (p. 387).

(II) The elevation of a mountain ridge or peak above the circumjacent area, as contrasted with elevation above the sea level, means, of course, the depression of the circumjacent area. This may be effected (1) by gravitational faulting, (2) by denudation.

(1) Gravitational faulting on a large scale appears to be chiefly exemplified in regions which have been elevated by the formation of a geanticline, notably in the Great Basin, to which reference has already been made. The Sierra and the Wasatch tower aloft as the piers of the broken arch whose ruins are seen in the fault blocks of the basin.

(2) Undoubtedly, in the vast majority of cases, ridges and peaks are remnants spared in a process of circumdenudation. The conditions to which the natural selection of these remnants is due may be (a) highly resistant rocks, or (b) a situation comparatively remote from the main lines of drainage of the region.

This analysis may be tabulated as follows:

Mountain elevation may be—
- (I) above sea level (mountain range or mass). This may be caused by
  - (1) deposit of material by epigene agencies;
  - (2) ascent of lava. The lava may be
    - (a) extruded at surface, forming volcanic cones, domes, lava plateaus;
    - (b) intruded below surface, forming laccoliths, bysmaliths, sills.
  - (3) Crustal movement (diastrophism). This may be
    - (a) epirogenic, probably isostatic;
    - (b) orogenic (wrinkling of crust due to internal contraction). This may be
      - (α) formation of a geanticline (anticlinorium); this type of folding often complicated with gravitational faulting.
      - (β) formation and subsequent crushing of a geosyncline (synclinorium; this type of folding often complicated with thrust faulting.
- (II) above circumjacent area (mountain ridge or peak). This may be caused by
  - (1) gravitational faulting;
  - (2) denudation. Remnants spared by circumdenudation may owe their preservation to
    - (a) highly resistant rocks;
    - (b) situation remote from main lines of drainage.

DISCUSSION

W. M. Davis: Mountains are geographical features; they are manifested through their topographic form. Hence a classification which lays stress chiefly on structure does not suffice; still less when the classification is based in part on the processes by which the structures are thought to have been produced. Among the ranges which Professor Rice has placed in the group of crushed or folded mountains there are some which have truly enough in an earlier cycle of erosion

Where massive portions of the granite are surrounded by well-jointed portions the latter yield to all erosive processes with relative ease, and the massive bodies survive as monadnocks with rounded forms. These are so abundant as to be familiar to all acquainted with the Sierra Nevada, and have received the distinctive name of "domes."

The properties by which rocks are enabled to resist erosive attack, mentioned in the order of their familiarity, are (1) hardness, (2) insolubility, (3) extreme permeability, whereby water is carried below the zone of frost action and eventually discharged through springs, and (4) continuity or massiveness.

LINEAMENTS OF THE ATLANTIC BORDER REGION

By WILLIAM HERBERT HOBBS, University of Wisconsin

INTRODUCTION

HISTORICAL

Since the time of Élie de Beaumont and the promulgation of his theory of the arrangement of mountain chains, the attention of geologists has been largely withdrawn from the orientation of earth features and focused on the areal distribution of geologic formations and the construction of geologic sections. It must be admitted that to this transference of effort has been due the great advance which geology has made in the period which has since elapsed. The question may now be asked, however, whether the accumulation of geologic data and the replacement of the crude maps of the earlier period by the accurate modern topographic map do not warrant a return, if not to the methods of de Beaumont, at least to a new and entirely different study of the orientation of surface features. May not too much attention be now directed to inference regarding the section, which is not often available for inspection, and too little to the ground plan of features which are everywhere open to study? The trend which has been given to geological thought in Europe, in particular by the Baron von Richthofen in Germany, by Commandant Barré and others in France, and throughout the continent of Europe by the distinguished Viennese geologist, Professor Suess, tend greatly to strengthen this conviction. The prominence which the theory of Green regarding the genesis of the broader features of the earth has of late acquired will further emphasize the importance of the directional element in topographic development.

The investigation discussed in this paper is an inquiry into the orientation of the dominating earth lineaments of the Atlantic border region in the United States with a view to determine whether they betray any law of systematic arrangement. The inquiry was suggested by the study of the southwestern New England area and the evidence discovered there of a complex fault mosaic, the limits of which can only be assumed to be far beyond the boundaries of the province studied. Such an investigation has not hitherto been made within the region, and the scope of the inquiry presents novel features.

CHARACTERISTICS OF JOINTS AND FAULTS

The data collected by geologists respecting joints and faults have until recent years not been of a sufficiently definite character to permit scientific correlation throughout large areas, or, in fact, even in very limited areas. Under the best present theory of the formation of block faults, their isolated occurrence is as little to be expected as would be the presence of an isolated anticline upon the present theory of folding, and it is believed, as a result of field observation, that individual faults unrelated to other planes of dislocation seldom occur. In all districts where they have been studied carefully a tendency of faults to appear, as do joints, within essentially parallel series has been remarked. Likewise there has been observed a more or less marked tendency of the minor faults to be spaced within such a series in approximation to uniformity, and this property, so characteristic of the joints with which they are genetically connected, is one demanded by our theory of their origin through regional compression, and one which is duplicated in the faults produced artificially by the compression of an elastic body, such as glass. Additional properties of joints which, it may be inferred, they have in common with faults, are that in regions which since their formation have been little disturbed the joint planes stand nearly vertical, and in their network two dominating series are generally found to be approximately normal to each other.

CONCLUSIONS FROM STUDY OF SOUTHWESTERN NEW ENGLAND

What is believed to be an important result of the study of the southwestern New England area is that lines of dislocation, while maintaining often with great fidelity a definite direction, do so in part along a plane whose course is the direction of the dislocation as a whole, but more largely along other planes which may make considerable angles with it, the course being here a series of zigzags. In these zigzags there may be recognized several definite recurrent directions, as well as several differing orders of magnitude, the lowest order having the joint planes for its elements.

TYPES OF EARTH LINEAMENTS

The more important lineaments of the earth physiognomy may be described as (1) crests of ridges or the boundaries of elevated areas, (2) the drainage lines, (3) coast lines, and (4) boundary lines of geologic formations, of petrographic rock types, or of lines of outcrops. Under the first head of particular significance are the lines of escarpment, the borders of upland areas, and the lines connecting cascades or rapids--fall lines. In so far as surface configuration has been brought about by the influence of fold structures within the underlying rocks,

the genetic relationship will be veiled under the complex curves that are characteristic of such structures, except where the latter are unusually simple. Any orientation of lineaments due to joints or faults, on the other hand, in so far as this influence is now apparent, will by contrast be indicated in a more or less marked tendency of lineaments to adhere to a fixed direction, and this direction should recur in the orientation of other lineaments within the province. If a system of joints or faults is extended over a broad area, approximate equivalence in the spacing of lineaments may be looked for as a possible additional indication of this origin, though regularity of spacing might equally well be due to folds. In so far as fault planes stand nearly vertical, as is the case in the post-Newark deformation of the Atlantic border region, the course of such structures should be but very little affected by the irregularities of the surface.

From the existence of several types of lineament, it is to be expected that one which is manifested for a greater or less distance upon the earth's surface as a distinct type—say a scarp—may be continued as another type—let us say as a drainage line—and this again may be extended by a third—it may be as a "fall line" which intersects lines of drainage, and this again by a geologic boundary, etc. This composite nature of extended earth lineaments tends to conceal their presence, and careful study will be necessary for their discovery.

PROJECTION OF LINEAMENTS ON MAPS

The observation made in smaller areas, that the course of a line of dislocation is not straight, but is made up of a great number of straight elements composing a series of zigzags, indicates that the lineaments which may appear rectilinear on the maps may be so only in proportion as the scale of the map is small. Such lineaments, if traceable to dislocation of the crust for the control of their direction, must be conceived to outline in the majority of instances a complex but comparatively narrow zone of displacements, in which other directions than that given by the general trend are included. The principal dislocation, while making excursions in zigzags upon either side of its axis, does not, however, it would seem, deviate very far from this average course. Such lines, if in reality the projection of plane surfaces within the crust of the earth, will upon maps, as usually constructed, appear as curves. This necessary correction in their delineation, like the influence of erosion in everywhere molding curving outlines, has often effectively obscured the architectural lineaments in the landscape. If such architectural elements are present they are for this reason little likely to force themselves upon our attention, and the key to their system will have to be sought out.

DRAINAGE SYSTEM OF CONNECTICUT

The evidence that a mosaic of joint and fault blocks has largely affected the drainage system of the State of Connecticut has been elsewhere presented.[a] It was found worthy of note, not only that the master streams adhere for long distances to rectilinear courses, and that after making considerable excursions to one side or the other they frequently return to these courses, but it was further determined that the drainage network discloses a number of parallel series within which approximation to equivalence of spacing is apparent (see map).

SCOPE OF INVESTIGATION

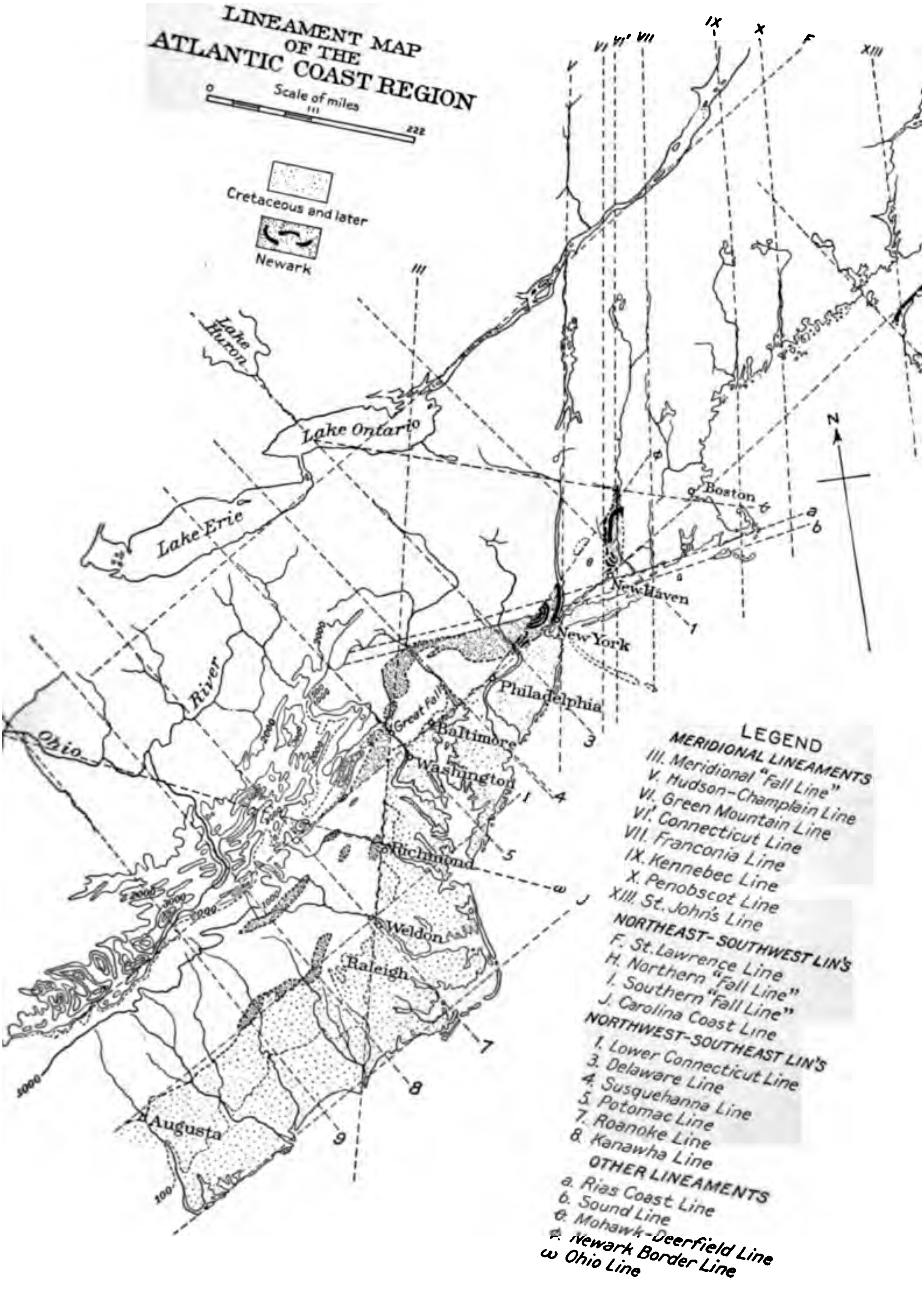
The discovery that essentially one system of control is indicated within this large area has added confirmation to the views of Davis, Russell, and the writer that the deformation by block faulting of the Newark rocks of the Atlantic border has been regional rather than local in its origin. It was this consideration which suggested the wider application of the same method of examination. The investigation has, however, been carried out not with a view to find certain directions among lineaments, but to fix the direction, if notably rectilinear, of all dominant lineaments, and further to see whether they reveal indi cations of arrangement within parallel series which approach to uniformity of spacing.

Due regard must be had to the danger of being misled by coincidence, yet the results of the study of the Atlantic border region are sufficiently remarkable to suggest the inquiry why these relationships have not before been made out. This must be explained by the localization of individual fields of study, by the so recent publication of accurate topographic maps, by the obscuring of topographic forms due to the overprinting of culture on maps (in which the black lines of railroads and highways are forced upon the attention), by the composite nature of lineaments, by the curvature of lineaments when projected upon maps, but more than all by the fact that definite orientation of lineaments has not generally been included in the field of inquiry of geology.

CONSTRUCTION OF MAP

For an inquiry into the orientation of earth lineaments the most accurate maps which are engraved on a practicable scale have been sought. The most satisfactory map for the locality here under consideration is that of the U. S. Geological Survey which is engraved on a scale of 1:7,033,000, or 111 miles to the inch. To form the base of the plate the main hydrographic lines only of this map have been traced, the culture being omitted. The official map itself and

[a] The river system of Connecticut: Jour. Geology, Vol. IX, 1901, pp. 469–484, pl. i. See also Connecticut rivers: Science (new series), Vol. XIV, 1901, pp. 1011-1012.


LINEAMENT MAP
OF THE
ATLANTIC COAST REGION
Scale of miles
0
111
222
Cretaceous and later
Newark
Lake Huron
Lake Ontario
Lake Erie
Ohio
River
Boston
New Haven
New York
Philadelphia
Great Falls
Baltimore
Washington
Richmond
Weldon
Raleigh
Augusta
N
LEGEND
MERIDIONAL LINEAMENTS
III. Meridional "Fall Line"
V. Hudson-Champlain Line
VI. Green Mountain Line
VI'. Connecticut Line
VII. Franconia Line
IX. Kennebec Line
X. Penobscot Line
XIII. St. John's Line
NORTHEAST-SOUTHWEST LIN'S
F. St. Lawrence Line
H. Northern "Fall Line"
I. Southern "Fall Line"
J. Carolina Coast Line
NORTHWEST-SOUTHEAST LIN'S
1. Lower Connecticut Line
3. Delaware Line
4. Susquehanna Line
5. Potomac Line
7. Roanoke Line
8. Kanawha Line
OTHER LINEAMENTS
a. Rias Coast Line
b. Sound Line
θ. Mohawk-Deerfield Line
φ. Newark Border Line
ω Ohio Line

the official map on the same scale printed in solid brown tones to indicate the zones of different elevation should, however, be consulted and compared with the map given here for the additional evidence they furnish. The last-mentioned map brings out with especial clearness the plateau areas of the region, owing to the fact that areas less than 100 feet, areas between 100 and 1,000 feet, between 1,000 and 2,000 feet, and above 2,000 feet are represented by shades of increasing depth of tone. Of especial value also in the same connection is the plate printed by Powell to accompany his paper on physiographic regions of the United States, since the borders of physiographic provinces correspond to important lineaments.

Lineaments have been extended on the map on the assumption that their course is the trace of a vertical plane through the crust of the earth; in other words, a great circle. For the longest indicated lineament (the line H) the direction was assumed from the position of the fall line at the two points, Baltimore and New York, and other points on the great circle determined by location, first, of the vertex, then of other points by the formulas used by navigators in great-circle sailing. For the meridional series, with the exception of the long Hudson-Champlain line, which is a great circle, the lines of the series are loxodromes. For the direction given these lines vary but little from great circles. This was found by trial to be true also for the northwest-southeast series on the map, owing to the fact that the medial line of the polyconic projection is far to the west.

SOME OF THE DOMINATING LINEAMENTS

In the time allotted me it is obviously impossible to point out on what grounds each lineament represented upon the map has been so designated. Study of the plate itself, in connection with the more elaborate maps above referred to, and especially with a geological map at hand, will reveal the true significance of these lines. The reduction in the scale of the map makes it necessary to omit the topography of all save the southeastern portion, but this should be carefully examined upon the official map and, if possible, the lines here indicated entered upon it.

To refer to but a few of the dominating lineaments, the line H in the series trending northeast and southwest is the well-known "fall line" between New York City and Washington. To the east of New York it follows first the rias coast of Connecticut, then the fault boundary of the Newark formation of the Connecticut Valley; next, rivers directed across the prevailing drainage and, crossing an arm of the sea, passes near the eastern bluffs of the Bay of Fundy. Southwest of Washington this line is for some distance the fault boundary of the Newark formation, and is extended as the eastern base of the

Appalachians at their junction with the Piedmont Plateau. For over a thousand miles, therefore, this line is followed as a topographic break; for much of the distance also as a geologic boundary. Parallel to this lineament are the great St. Lawrence line (F), the southern "fall line" (I), and the coast line of the Carolinas (J). The St. Lawrence for a part of its course has been recognized as a line of faulting.

In the meridional series, perhaps, the most remarkable line is that along the Hudson River, Lake Champlain, and the Richelieu and Croche rivers in Canada (V), which for much of its distance has been recognized as a line of faulting, and which marks out for 600 miles an earth lineament interrupted for but short distances only. Far to the south and to the east of the North Carolina coast the continental plateau plunges into deep water along this extended lineament. The meridional "fall line" (III), from the Great Falls of the Potomac southward, is well-defined as a fall line as far as Weldon, N. C., beyond which its course may still be followed. This direction, like the others of the series, runs about 5° east of the meridian. Hardly less interesting is the line followed upon the land in a direction about as far to the west of the meridian (N. ± 5° W.) and passing through Baltimore. Extending southward this lineament follows the western shore of Chesapeake Bay, and, passing through offsets of most of the rivers which it crosses, it is to the east of Florida the steepest eastern scarp which anywhere characterizes the continental shelf—a scarp nearly 900 miles in length.[a]

In the region southwest of New York City, the intersection of the northeastwardly directed lineaments by a series extending nearly at right angles to them divides the crust into a number of short rectangles, in the manner of a checkerboard. This network, disclosed by the drainage lines, is extended across the continental shelf by the original channel of the Delaware, and, to a less degree, by the ancient channel of the Hudson.

The three series of lineaments thus briefly referred to are the meridional series (N. 5° E.), a second series averaging 50° east of the meridian, and a third series near 43° west of the meridian. It will be noted that there is less correspondence between the rivers outlining lineaments in this last series than in the other two. The line along the Saint Johns River has the direction N. ± 33° W. (see line XIII on map). The others have been drawn on the map as about N. 43° W., but it is noticeable that west of the Appalachians the markedly rectilinear streams which approach their direction have the direction north ± 33° west. The directions N. 34° W. and N. 44° W. were found to characterize many faults in the Pomperaug Valley, Connecticut, and the

[a] See U. S. Geological Survey relief map by Howell, of the United States and the Gulf of Mexico, with portions of the Atlantic and Pacific oceans. Modeled on a globe 16½ feet in diameter. Horizontal scale 40 miles to the inch. Vertical scale 8 miles to the inch.

same divergence of northwestward-flowing streams was made out. With the individual exceptions shortly to be mentioned, the lineaments comprising these three series clearly constitute the stronger tectonic lines of the region—the lines indicated by the larger rivers, the coast line, the formation boundaries, the borders of plateaus, the main mountain ranges, and the boundaries of physiographic provinces. Larger scale maps than the one used would reveal many other directions, several of which are shown upon the map, and careful search of the map here used as a base would bring out new lineaments, both in the series mentioned and in other series. The aim has been, however, to draw attention to the dominating lineaments only.

CHARACTERISTICS OF THE NETWORK OF LINEAMENTS

From what has been said it would appear that the dominant lineaments of the Atlantic coast region of North America are largely included in a nearly meridional series and in two other series which make nearly equal angles with this direction. Other lineaments, which more closely approach the equatorial direction, vary more from one another, and are both numerically less important and less strikingly brought out. It can hardly be regarded as accidental that in all of the three series the spacing should approximate so closely to uniformity, or, when intervals of exceptional width occur, that they should constitute multiples of the normal intervals. This uniformity of spacing is indicated in the numeration adopted for the lineaments on the map. The normal interval of the meridional series is, in the latitude of Boston, about 40 miles; that for the northwest-southeast trending series is about 75 miles, while that for the northeast-southwest series approximates 125 miles. As already pointed out, some approach to uniformity of interval within a series should be expected if the lineaments are to be referred to disjunctive processes and if faults of similar magnitude are spaced with the same regularity as are the joints with which they are genetically connected.

Inspection of the map reveals the fact that the area lying east of the Hudson-Champlain line is noticeably different, as respects the dominance of its striking lineaments, from the area lying west of the same dividing line; since in the area east of this boundary between physiographic provinces the control of topography and of drainage has been exercised largely by the meridional direction. A rectangular or checkerboard structure is evident in the region of the Middle Atlantic States, as a result of the dominance of the northwest-southeast and northeast-southwest elements.

EVIDENCE THAT SYSTEMS OF REGIONAL JOINTS EXTEND OVER WIDE AREAS

Comparatively few geologists have put on record the directions of prevailing joints within the regions which they have studied. Until such studies have been undertaken the fragmentary records now at hand must be found insufficient for satisfactory correlation throughout large areas. There are, however, some indications that they will be found to be more generally in accord than has usually been supposed.

The most comprehensive studies of the joint directions which have been made in the United States are those by Shaler and Tarr[a] in Massachusetts and by Buckley[b] in Wisconsin. The first mentioned study is a comprehensive investigation and elaborate averaging of all joints which were observed within a small district of complex structure; the last mentioned, on the other hand, a comparison of the master joints found at numerous widely separated localities within a large area in Wisconsin. Shaler and Tarr in the Cape Ann district found that the joints are included in a large number of series and are quite uniformly spaced within each series. Measurements of the joint intervals were in many cases made. For the area as a whole it is found that the greater number of joints trend in the directions N. 20° to 25° W., N. ±90° E., N. 30° to 35° E., N. 45° to 50° E, N. to N. 5° W., N. ±15° E., and N. 30° to 35° W.; the order named being the order of their relative abundance. Joint directions were taken with a compass and measured to the nearest 5°.

Investigations of another great quarry region in Massachusetts by Crosby[c] show that the planes of jointing fall into approximately vertical and parallel series, the prevailing trends of which are either meridional or equatorial, though associated with other directions.

In the areas lying within the uplands of southwestern New England, which the present writer has studied in detail, a correspondence of fault and joint directions has been established, and it is found that for both alike the dominant directions are near the meridian (N. ±5° W.); near the equatorial direction (N. 85° to 90° W.), and in intermediate directions, particularly N. 50° to 55° E., N. 15° E., N. ±34° W., and N. ±44° W.

Cushing has described the joints and faults of Rand Hill, in northern New York State.[d] He describes the master joints as trending princi-

[a] Shaler, N. S., The geology of Cape Ann, Massachusetts: Ninth Ann. Rept. U. S. Geol. Survey, 1887-1888, 1889, pp. 529 611.

[b] Buckley, E. R., On the building and ornamental stones of Wisconsin: Bull. IV, Wisconsin Geol. and Nat. Hist. Survey, 1898, pp. 456-460, pl. lxix.

[c] Crosby, W. O., Geology of the Boston basin, Vol. I, part iii: The Blue Hills complex; Occasional papers, Bost. Soc. Nat. Hist., Vol. IV, p. 340, pl. xvi.

[d] Cushing, H. P., Geology of Rand Hill and vicinity, Clinton County: Nineteenth Ann. Rept. State Geologist, New York State Museum, 1901, pp. 39-82, map.

pally along the meridian, or parallel to the equator. Other sets cut these directions at about 45°. He adds, however, that many joints have been noticed which can not be brought into any of these sets, but that these are of much less importance.

As a result of his extended study of joints throughout the State of Wisconsin, Buckley has made the following summary:[a]

> As will be seen in the accompanying map, the joints of the sedimentary rocks strike in four main directions. The prevailing general direction of the joints is northeast and southwest. The other directions are northwest and southeast, east and west, and north and south.

Insufficient as is the evidence for a satisfactory correlation of joints and faults within the area studied, it is at least accordant and strongly favors the view that master joints and master faults as well are not without relations to one another, even though separated by distances which may constitute an appreciable portion of the earth's circumference. The nearly meridional direction of jointing was found to be dominant in all the areas studied from Massachusetts to Wisconsin. The nearly equatorial and the two intermediate directions were the remaining directions of master joints in all save one of the districts examined—the Boston basin—and here the meridional and equatorial directions alone controlled. Observations by the writer in southwestern Wisconsin reveal there the same four directions of master joints occurring with others of less importance. It is to be hoped that other investigators will give attention to the orientation of joint planes in connection with their study of local districts and put the results of their study on record.

RELATION OF LINEAMENTS TO THE GRANDER FEATURES OF THE EARTH

It must be evident that if the master lineaments within a large area reveal a control by disjunctive processes of the same type and are referable to a single system or network, their explanation must be sought in considerations which are far removed from local conditions of isostatic crustal adjustments. Lineaments which can be followed 1,000 miles as a definite and rather striking border of plateaus (H), which are individualized physiographically and geologically, must have an important relation to the orography of the earth as a whole. This idea has been brought out elsewhere by Suess in connection with his study of an almost antipodal region in east Africa, where the dislocations observed were too extended to be explained by local conditions.[b] The stronger lines of displacement being there, as in many

[a] Loc. cit., p. 459.

[b] Suess, Edward, Die Brüche des Östlichen Afrika: Beiträge zur geologischen Kenntniss des Östlichen Afrika, by von Hohnel, Rosinal, Toula, and Suess; Part iv, pp. 135, 139. Special reprint from Denkschriften d. math. naturw. Klasse k. Akad. Wiss., Wien.

other regions, meridional or nearly so, Suess has suggested that they are connected with a fracturing of the planet, considered as a whole.

Even more worthy of consideration in this particular are papers by Baron von Richthofen, dealing with the geomorphology of eastern Asia,[a] in which it is clearly shown that the grand features of the entire Pacific coast of Asia are arranged in a system of network made up of a series of tilted plateau-like blocks, the arc-like boundaries of which give form to the great plateau area, as well as to the Asiatic coast line and to the festoons of islands which fringe it. According to von Richthofen, the meridional and diagonal series of lineaments are in each case tectonic lines of displacement; the equatorial series, which joined to the meridional ones produce the arcs, are in part explained by fold structures. The individual tectonic lines of the series are in some cases 700 miles or more in length, while continuous zigzagging series nearly cross the continent.

Of interest also in this connection is the paper by Prinz,[b] which deals with the cardinal orientation of the grand features of the earth and of the other planets in the solar system. Prinz finds that the earth and, so far as their maps permit generalization, the planets Mercury, Venus, Mars, and Jupiter betray grand features arranged in two nearly rectilinear sets running northwest-southeast and northeast-southwest, respectively, with an intermediate set directed nearly along the meridians. Following Schiaparelli, who has furnished the remarkable maps of Mars and Mercury, he attributes these networks to geotectonic forces affecting the planet as a whole, and in the case of the earth he sees evidence of torsion operative between the northern land and the southern sea hemispheres along the twin plane of Green in such a manner as to produce systems of joints analogous to those brought out in glass by the experiments of Daubrée and Tresca.

It follows, from the conception of the zones of fracture and flowage within the lithosphere, that under the causes which operate to produce crustal shortening, the stresses will be relieved within the outer shell by fracture at the same time that adjustment is secured by folding in the more deeply buried portions. With the progress of degradation the folded portions of the crust, so far as they are uncovered by such a process, will be successively brought within the zone of fracture; and, under the operation of forces of the same type as those which produced their folds, will now be deformed by fracture. Such deformation by fracture will be necessarily superinduced on the earlier developed fold structures and particularly when accompanied by displacement should most profoundly modify the surface architecture,

[a] Geomorphologische Studien aus Ostasien, i-v: Sitzungsb. d. königl. preuss. Akad. Wissensch. zu Berlin, 1900-1904. Partial translations have appeared in consecutive numbers of the American Geologist, beginning August, 1904, under the title, Tectonic Geography of Eastern Asia.

[b] Prinz, W., Sur les similitudes que présentent les cartes terrestres et planetaires (Torsion apparente des planètes): Ann. de l'Observatoire royale de Bruxelles, 58th year, 1891, pp. 304-337.

both before and after denudation. In a region in which both folds and normal faults are present, the faults must be later and hence the more likely to influence the physiographic development.

Considering the bearing of the above survey, it is interesting to read the summary by Russell[a] after his correlation study of the Newark areas of the Atlantic border, which are scattered from one end to the other of the area here examined:

> An examination of the entire system shows that faulting is as important an element in the structure of the Atlantic coast plain as it is in the Great Basin. These two regions have this important difference: In the Great Basin fault scarps stand in relief and form mountain ranges, while along the Atlantic coast the relief has been subdued by erosion, and for the most part a featureless plain takes the place of the mountain uplifts that would otherwise appear.
>
> It is to be supposed that the faults traversing the Newark rocks are but a portion of a great system which affects a large part, and perhaps the entire region, of metamorphic rocks, in the midst of which remnants of the Newark system have been preserved.

It is perhaps significant that the most remarkable study of the orientation of earth lineaments has been carried out upon the continent of Asia, where geological and geographical study by a single observer has been made to cover a vast area and where of necessity attention has been focused upon the broader rather than upon the local features.

[a] Bull. U. S. Geol. Survey No. 85, 1892, p. 98.

THE GEOGRAPHY OF ALASKA, WITH AN OUTLINE OF THE GEOMORPHOLOGY

By ALFRED H. BROOKS, United States Geological Survey

INTRODUCTION

The rapid commercial development of Alaska within recent years has drawn public attention to this little-known part of the earth's surface and led to the inauguration of many exploratory surveys and investigations. So actively has this work been pushed, both by public and private enterprise, that knowledge of the geography, geology, and mineral resources has grown more during the past decade than during the preceding twenty-eight years which had elapsed since the acquisition of the territory by the United States. While the mapping of the shore line has fallen to the Coast and Geodetic Survey, the surveys and explorations in the interior have been for the most part done by the Geological Survey.

An attempt to summarize this knowledge has already been made in a report[a] now in print, containing numerous illustrations. It is the purpose of this paper merely to sketch in outline the salient geographic features of Alaska and to discuss briefly their genesis, so far as the data at hand will permit. The task is rendered difficult because the extent of this province and its complexity of topography demand a more extensive exposition than could find place in this volume. Moreover, many links in the chain of evidence are lacking, which must render descriptions and discussions more or less incomplete. As the writer is familiar by personal observation with only a part of this field, many of the facts to be presented have been determined by the work of others.[b]

[a] Brooks, Alfred H., The geography and geology of Alaska, a summary of existing knowledge: Prof Paper U. S. Geological Survey No. 45.

[b] Although the writer is indebted to all his colleagues engaged in the Alaskan surveys, he is under special obligations to geologists F. C. Schrader, W. C. Mendenhall, Arthur C. Spencer, J. E. Spurr and Arthur J. Collier, and to topographers T. G. Gerdine, D. C. Witherspoon, E. C. Barnard, and J. W. Peters.

DESCRIPTIVE GEOGRAPHY

GENERAL FEATURES

Alaska, the largest noncontiguous possession of the United States, is that great land mass which forms the northwestern extremity of the North American continent, its western point lying within 60 miles of the Asiatic coast. About one-quarter of this area is within the Arctic Circle and must be regarded as an arctic province, but the extensive southern seaboard, exposed to the warm winds and waters of the Pacific, gives to the entire southern portion of the territory[a] a comparatively warm climate.

Alaska in its greatest extent is included between meridians 130° west longitude and 173° east longitude and between parallels 54° 40′ and 72° north latitude. It is bounded on the north by the Arctic Ocean, on the west by the Arctic Ocean, Bering Strait, and Bering Sea, on the south and southwest by the Gulf of Alaska and the Pacific Ocean, and on the east by Yukon Territory and British Columbia. The eastern boundary from the Arctic Ocean to the neighborhood of Mount St. Elias is the one hundred and forty-first meridian; thence southeastward to Portland Canal it is irregular. The area of Alaska is about 590,000 square miles, or about one-fifth of that of the United States.

The general outline of the territory suggests a peninsula of rectangular form, cut out of the continent by Mackenzie Bay on the north and the Gulf of Alaska on the south. Two peninsulas of considerable size stretch out toward Asia, the Seward Peninsula, which, with the Chukchee Peninsula of Siberia, divides Bering Sea from the Arctic Ocean, and the Alaskan Peninsula, which, continued in its archipelagoes, the Aleutian Islands and Commander Islands, cuts off Bering Sea from the Pacific Ocean.

The coastal topography is of two general types; first, that having a smooth, gentle contour, and, second, that which is precipitous and irregular. North of the Alaskan Peninsula the coast line is regular and consists typically of long stretches of sandy beaches, from which, on the one hand, the land rises with low gradient, and, on the other, the ocean floor slopes gently seaward. East and south of the Alaska Peninsula the coast line is characterized by great irregularities, its continuity being broken by many embayments. Here bold, rocky slopes rise precipitously from the sea, and deep water is found close to land. This Pacific coast region, with its irregular shore line, falls within the glaciated area of Alaska, while along the western and northern coasts glaciation is entirely absent.

[a] Although Alaska is usually designated a "Territory," legally it is an unorganized territory, district, or colony, as it has not a Territorial form of government.

Around the Gulf of Alaska the Pacific coast line makes a deep reentrant angle (see map), which is bounded on the east by the Panhandle, usually called southeastern Alaska, and on the west by the Alaskan Peninsula. It will be noted that the axes of the dominant mountain chains undergo, too, a marked change in direction, parallel to the crescent-like bend of the southern coast line. A study of the geology goes to show that this is the topographic reflection of an important structural feature.

In the main the larger physiographic features of Alaska are similar to those of the western United States (see map). The highlands, like those of the United States and Canada, lie parallel to the coast line; and the investigations of Doctor Dawson[a] and others have shown that the four topographic provinces of the western United States continue fairly well defined through Canada and Alaska. These four provinces may be described briefly as follows: A broad, mountainous belt—designated by Major Powell[b] the Pacific Mountains, but here referred to as the Pacific Mountain system—including the Coast Ranges of California, Oregon, and Washington, the Sierra Nevada and the Cascade Range, extends along the western margin of the United States and continues northward into Canada. East of this lies the Central Plateau region, or Great Basin, as it is usually called, essentially a province of high plateaus with some mountain ranges, and it, too, finds its northern counterpart in British Columbia. The eastern limit of this plateau region is marked by a number of parallel ranges, grouped together under the name Rocky Mountain system,[c] which again, like the Pacific Mountain system, extend into Canada. To the east of the Rocky Mountain system are the Great Plains, which stretch northward to the Arctic Ocean. The lines of demarcation between these provinces are usually sharply drawn. Each is of a dominant topographic type, though each exhibits many minor topographic subdivisions.

In British Columbia and Alaska the Pacific Mountain system or westernmost of these four provinces is a mountainous belt 50 to 200 miles in width, which properly includes the mountainous Alexander Archipelago and Aleutian Islands, as well as a number of smaller groups of islands. While this region is in the main rugged and mountainous, its ranges are distinct and often separated by broad valleys, including several large basins like that of the Copper River, and are broken by indentations of the coast line like those of the panhandle. Except for a section of the inner slope which drains into the Yukon

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[a] Dawson, G. M., On the later physiographical geology of the Rocky Mountain region in Canada: Trans. Royal Soc. Canada, Vol. VIII, sec. 4, 1890. Geological record in the Rocky Mountain region in Canada: Bull. Geol. Soc. America, Vol. XII, 1901, pp. 57-92.

[b] Powell, J. W., Physiographic regions of the United States: Nat. Geog. Soc., mon. 1, pp. 96-100.

[c] Major Powell terms these the Stony Mountains, op. cit., p. 100.


GEO

and Kuskokwim, its waters reach the Pacific through streams flowing transverse to the axis of the mountains.

East and north of the Pacific Mountains is the Central Plateau region, corresponding in a broad way with the Central Plateau of the western United States and Canada. The term plateau can be assigned to only a portion of this province, and even that is not a plateau in strict sense. It represents rather the remnants of a former plateau surface, through which rivers have trenched broad channels. The interstream areas, much dissected by erosion, give the effect of a gently rolling upland of comparatively low relief, which slopes away to the north and west. This belt is drained largely by the Yukon and Kuskokwim rivers into Bering Sea. The lowland areas bordering the streams are often of considerable extent; notably the flats of the Middle Yukon and Upper Kuskokwim and the lowlands which extend along Bering Sea adjacent to the deltas of the Kuskokwim and Yukon.

East and north of the plateau province the third geographic division is found in a broad cordillera, which is the northern extension of the Rocky Mountain system. The ranges of this division, like those of the Pacific Mountain system, also undergo a marked change in direction. At first they preserve the northwestward trend shown in the United States, but swing to the southwest at the Arctic shore, which they touch again north of Bering Strait. The drainage of the southern slopes of the mountains is chiefly tributary to the Yukon; that of the northern slopes reaches the Arctic Ocean.

The Great Plains east and north of the Rockies form the fourth province. In Alaska this is represented by an area of low relief which lies between the western extension of the Rocky Mountains and the Arctic Ocean and is designated the Arctic slope region. This area, like the corresponding one in the western United States, is really a slightly elevated plateau with a gently rolling surface which slopes to the north from the foothills of the Rocky Mountains and is dissected by the valleys of rivers whose waters flow northward into the Arctic.

PACIFIC MOUNTAIN SYSTEM

The Pacific Mountain system embraces a broad zone of ranges parallel to the southern coast line of Alaska and forming like it a reentrant angle, or more properly, a curve concave toward the south. The system is broadest near the apex of the angle, narrowing toward the southeastern boundary of the territory on one hand and toward its southwestern limit in the Alaskan Peninsula on the other.

Besides numerous inferior transverse lines of height, this system embraces four important ranges whose extended axes are approximately parallel to one another and to the general trend of the coast line (see map). Of these the Coast Range, the St. Elias Range, and

the Aleutian Range lie adjacent to the coast, while the Alaskan Range is inland and forms the northern border of the system.

The Coast Range extends from near the boundary of Washington northward through British Columbia and southeastern Alaska. Following the coast line for nearly 900 miles it passes inland behind the St. Elias Range near the head of Lynn Canal. Thence it can be traced northward, decreasing in altitude and gradually losing definition, until it finally merges with the interior plateau near Lake Kluahne in longitude 138° 30′.

This range has no well-defined crest line but is rather a complex of irregular mountain masses that occupy a coastal strip between the Pacific Ocean and the Central Plateau region. Both Hayes[a] and Dawson[b] have called attention to the uniformity of the summit levels between altitudes of 5,000 and 6,000 feet in Alaska and 8,000 and 9,000 feet in British Columbia.

The limits of the Coast Range are not always sharply defined, as in many places it merges with the Central Plateau, and on its seaward side is sometimes not clearly differentiated from the mountains of the Alexander Archipelago. Its width is about 100 miles near Fraser River, but decreases to about 50 miles near Lynn Canal.

The name St. Elias Range has usually been applied to the rugged mountain mass along the coast of Alaska between Cross Sound and Mount St. Elias, but here is given a broader significance and includes the Chugach, Kenai, and Scolai mountains, which are orographically a western extension of the St. Elias Range. The mountains of the Alexander Archipelago are properly a southeastern extension, but as they are separated from the mainland and divided into different groups by broad tidal waterways they can hardly be included under the same name.

Thus defined, the St. Elias Range extends northwestward from Cross Sound, bends westward near the mouth of Copper River, and near the head of Prince William Sound, in longitude 147°, turns sharply southwestward and merges into the highlands of the Kenai Peninsula. Near the one hundred and forty-second meridian the chain is parted by the valley of the Chitina River into two divergent ranges. The southernmost, here called the "Chugach Mountains," continues the main range across the head of Prince William Sound. The northernmost, under the name of Nutzotin and Skolai mountains, stretches westward and forms a connecting link between the St. Elias and Alaskan ranges.

The St. Elias Range is a rugged mass throughout its extent, varying in width from 50 miles near Cross Sound to nearly 100 miles at Mount

[a] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., Vol. IV, 1892, p. 128.

[b] Dawson, G. M., Report on the area of the Lamaloops map sheet, British Columbia: Ann. Rept. Geol. Survey, Canada, new series, Vol. VII, 1894, p. 10B.

St. Elias, and then narrowing to less than 20 miles to the southwest, in the Kenai Peninsula.

Near Cross Sound some peaks of the Fairweather group rise abruptly from tide water to altitudes of over 15,000 feet. Westward the range increases in height and complexity, culminating in Mount St. Elias and Mount Logan, 18,024 and 19,500 feet high, respectively. Here the mountain front is 20 to 30 miles from the coast, and the intervening space is occupied by a series of foothill ridges or a shelving coastal plain, in many places covered by huge glaciers. This part of the range presents a front unbroken from Cross Sound to the Copper River save for the broad valley of the Alsek River.

West of St. Elias the southern fork, called the Chugach Mountains, stretches parallel to the coast, skirting the northern shore of Prince William Sound, then bending to the south, merging finally in the lesser heights of the Kenai Mountains. It is there also a complex mountain mass, about 50 miles in width, whose peaks reach altitudes of 8,000 to 10,000 feet, and unbroken except where traversed by the valley of the Copper River near the one hundred and forty-seventh meridian. The summits of these mountains resemble those of the Coast Range in uniformity of altitude, giving them a plateau-like[a] character.

The Talkeetna Mountains,[b] a minor range lying northwest of the Chugach Mountains and separated from them by the valley of the Matanuska River, form an isolated highland mass, which belongs neither to the Chugach nor the Alaskan mountains. Their highest peaks probably reach altitudes of 5,000 to 6,000 feet.

The Copper River Plateau is a broad, flat depression drained by the Sushitna and Copper rivers, and hemmed in by the Chugach Mountains on the south, the Talkeetna Mountains and Alaskan Range on the west and north, and the Wrangell Mountains on the east.

Toward their western limit the Chugach Mountains give place to the lesser heights of the Kenai Mountains (Pl. VII), occupying the eastern half of the Kenai Peninsula.[c]

The Skolai Mountains, already alluded to as the branch of the St. Elias Range, extend westward until cut off by the head of the Copper River. On the north they are separated from the Nutzotin Mountains by valleys of streams tributary to the Upper Tanana, and on the south they merge into the Wrangell group. The Skolai Mountains are

[a] Schrader, F. C., and Spencer, A. C., Geology and mineral resources of the Copper River district: U. S. Geol. Survey, 1901, p. 65.

[b] Eldridge, G. H., A reconnaissance in the Sushitna basin and adjacent territory: Twentieth Ann. Rept. U. S. Geol. Survey, Part VII, 1900, p. 8. Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River: Twentieth Ann. Rept. U. S. Geol. Survey, Part. VII, 1900, p. 297.

[c] Mendenhall, Walter C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, Part VII, 1900, p. 296.

rugged, with altitudes of 7,000 to 10,000 feet. Schrader and Spencer[a] have called attention to their even crest line.

The Wrangell Mountains are an irregular group of volcanoes which lie between the two forks of the St. Elias Range. They are described by Mendenhall[b] as follows:

The Wrangell group occupies a rudely elliptical area, with the extensive lowlands of the Copper and Chittyna valleys on the south and west, but connected toward the east with the somewhat greater heights of the St. Elias alps. A well-marked depression on the north, which extends from the upper Copper across the Nabesna and the Chisana to the White, separates them from the neighoring Nutzotin and Mentasta ranges. Measured along the greater diameter of the ellipse from Scolai Pass northwestward to the outer base of Mount Drum, the extent of the group is about 100 miles, while the outer diameter at right angles to this is approximately 70 miles in length. Within this area of 5,500 square miles are at least 10 snow-clad peaks 12,000 feet or more in height. Several of these are unnamed, and two of them, Mounts Sanford (16,270 feet) and Blackburn (16,140 feet), are higher than Mount Blanc or any of the peaks within the borders of the United States.

The Aleutian Range, the third of the coastal ranges embraced by the Pacific Mountain system, forms the backbone of the Alaskan Peninsula. It rises directly from the sea near the southwestern extremity of the peninsula, and trends northeastward, skirting the Pacific shore as far as the entrance to Cook Inlet, beyond which a lowland 10 to 20 miles in width breaks the continuity of the range. Here the axis is offset to the west, and thence the mountains can be traced northward to about latitude 61°, were they fall off abruptly to a lowland. The northern portion of the range lying adjacent to Cook Inlet has been called the Chigmit Mountains. The mountainous Aleutian Islands, stretching nearly 900 miles westward from the mainland, are a southwest continuation of the Aleutian Range. Their shore lines are abrupt and rocky and their relief is very strong.

The greatest width of the Aleutian Range, almost 80 miles, is near latitude 58°, where their topography is complex and irregular. Northward it rapidly narrows until, at Cook Inlet, it becomes a single ridge. Its present relief is due, for the most part, to volcanic ejecta, and is made up of a series of volcanic peaks distributed at irregular intervals along a northeast-southwest axis. Redoubt Volcano, the most northern of these, is somewhat over 11,000 feet in height.

The Alaskan Range, the northernmost member of the Pacific system, is a rugged highland that extends northeastward from the vicinity of Lake Clark and sweeps around the great Sushitna and Copper River basins, forming the watershed between the Pacific drainage on the south and east and the Kuskokwim and Yukon waters on the north and west. The axis of the range, which is crescent-shaped, trends northeastward from the vicinity of Lake Clark to the one hundred and fifty-first

[a] Geology and mineral resources of a portion of the Copper River district, Alaska: U. S. Geol. Survey, 1901, p. 65.

[b] The Wrangell Mountains, Alaska: Nat. Geog. Mag., Vol. XIV, 1903, pp. 399-400.

meridian, thence eastward to the Tanana Valley, thence southeastward to the Nutzotin Mountains, which link it to the St. Elias Range.

Its crest line, which is well defined and remarkably regular, lies close to the western margin. On the east and south a series of foothills intervene between the range and the lowlands of the Sushitna Valley and the Copper River Plateau. On the west the mountains fall off abruptly to a gravel plateau which slopes westward and merges into the Kuskokwim lowland. The north front shows an equally abrupt transition to the lowland of the Tanana Valley. The northern and western base line of the Alaskan Range is remarkably even for 200 miles.

The mountainous belt which constitutes this range averages 50 to 60 miles in width. As the crest line lies near the western margin, the eastern drainage flows through deep-cut valleys before emerging on the lowland of the Sushitna River Valley. This fact and the greater precipitation on the coastal side of the divide makes the streams tributary to the Pacific watershed much larger than those flowing to the west and north, which, rising in glacial cirques, thread the mountains in short valleys and then debouch upon the gravel-floored plateau beyond.

No altitudes have been determined in the almost unexplored southern end of the range, but the highest peaks there probably do not exceed 5,000 or 6,000 feet.[a] Toward the north the relief increases near the sixty-second parallel to a height of 10,000 feet. In this region Mount Spurr,[b] south of the Yentna basin, has an altitude of 10,500 feet, while Mount Russell[c] and Mount Dall,[d] north of the Yentna basin, reach elevations of 11,300 and 9,000 feet, respectively.

Spurr[e] gave the name "Tordrillo Mountains" to that part of the Alaskan Range south of the passes connecting the Skwentna and Upper Kuskokwim drainage basins. Their peaks reach 6,000 to 7,000 feet in altitude. The broad valley of the Upper Kuskokwim separates them from an area of lesser altitude, termed by Spurr the "Terra Cotta Mountains," which is also an integral though subordinate part of the Alaskan Range.

The culminating peaks of the Alaskan Range are Mount McKinley, 20,300 feet, the highest on the continent; and 14 miles to the south, Mount Foraker, 17,000 feet, both in about latitude 63°. These two are dome-shaped and tower far above the adjacent mountains, which are 10,000 to 11,000 feet high. They are visible from Cook Inlet and have been known to whites for more than one hundred years, but

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[a] The writer is indebted for this information to Mr. Wilfred H. Osgood, of the Biological Survey, Department of Agriculture, who visited Lake Clark in 1902.

[b] Named after J. E. Spurr by the writer.

[c] Named after I. C. Russell by the writer.

[d] Named after William H. Dall by the writer.

[e] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, Pt. VI, pp. 31-264.

were not indicated on maps until recently. Mount McKinley was known to the Russians as "Bulshaia" and to the natives of Cook Inlet as "Traleyka." Both names signify high or big mountain. In 1895 it was named Mount McKinley by W. A. Dickey, who ascended the Sushitna River for a short distance and called attention to its tremendous height. In 1898 George H. Eldridge and Robert Muldrow, of the United States Geological Survey, determined its position and altitude, and the following year Lieut. Joseph S. Herron named the second high peak "Mount Foraker." In 1902 a more extended exploration of the range was made by Alfred H. Brooks and D. L. Reaburn, who were the first white men to reach the base of Mount McKinley.

Near the Cantwell River, to the northeast, the range decreases in altitude to 7,000 and 8,000 feet, but still farther east the relief again increases, and where the mountains skirt the southern side of the Tanana Valley there is a group of peaks 9,000 to 14,000 feet in height.

CENTRAL PLATEAU REGION

North and west of the rugged snow-covered ranges of the Pacific Mountain system the aspect of the country changes abruptly. A rolling upland about 200 miles wide, deeply dissected by well-developed drainage systems, with streams, valleys, and broad lowlands, and diversified by scattered mountain masses and isolated peaks that rise above the general level, stretches from the mountain front to the Rocky Mountain system on the north and from the lowlands which skirt Bering Sea to and beyond the International Boundary.

The larger part of this province is characterized by a striking uniformity in the summit levels of the interstream areas. These summits are, in fact, the remnants of a former plateau which has been deeply dissected, and from this dominant topographic feature the province takes its name, the Central Plateau region.

Near the northern boundary of British Columbia the plateau at its western margin has an altitude of about 5,000 feet, from which it slopes down toward the center of the province and probably rises again toward the Rocky Mountain front. It also declines northwestward to an altitude of about 4,000 feet, near the intersection of the sixty-third parallel with the Yukon. Thence the plateau stretches to the northwest as far as the great bend of the Yukon; then, encircling the broad lowland known as the Yukon Flats, it falls off still more to the southwest, until it has an altitude of less than 2,000 feet near the Lower Ramparts, in latitude 66°. North of this, in the Koyukuk region, the plateau level is apparently represented by hills whose summits stand at altitudes of about 3,000 feet.[a]

[a] Schrader, F. C., Reconnaissance along the Chandlar and Koyukuk rivers, Alaska: Twenty-first Ann. Rept. U. S. Geol. Survey, Part IV, 1900, pp. 441-486.

The region lying northeast of the Yukon has been little explored, but the plateau probably stretches to the front of the Rocky Mountain system. In the lower Yukon and Kuskokwim region the topography is characterized by broad lowlands, interrupted by irregular hills which seldom rise above 2,000 feet and decrease in height toward the coast. These appear to be remnants of the plateau which probably declines to an altitude of less than 1,000 feet near Bering Sea.

Although the Seward Peninsula falls within the plateau province, it gives less definite indications of the plateau feature itself. The characteristic[a] topographic types are rounded hills and ridges, from 800 to 2,000 feet in height, which form an irregular upland that usually rises away from the coast and is broken by many broad valleys with gentle slopes and occasional basin lowlands of considerable extent.

In northern British Columbia the line between the plateau and Coast Range is not sharply drawn because of a gradual blending of the topography of the two provinces. In Alaska, on the other hand, the change from plateau province to the bounding mountain ranges is in many places very abrupt. This is the case along the northern front of the St. Elias Range, where the flat, smooth, grass-covered summits end abruptly against the steep slopes of the rugged, snow-topped mountains. The relations of the plateau and the Rocky Mountain ranges are less well known, and will not here be discussed.

In British Columbia there are a number of well-defined ranges within the central plateau region, but these die out to the northward, and in Alaska the province includes no important ranges. Isolated peaks which rise above the level are not uncommon, and there are a number of minor ranges, such as the Glacial Mountains in the Yukon Basin, the Oklune Mountains in the Kuskokwim region, and the Kigluaik Mountains in the Seward Peninsula, which stand above the level of the plateau.

As the plateau approaches Bering Sea it gradually loses its distinctive features, the valleys broaden, interstream areas grow smaller and lower, and finally, 100 miles or more from tide water, the uplands end and the valley floors merge into the coast plain which skirts the eastern shore of Bering Sea. Besides the coastal plains there are also large lowland tracts included in the plateau province. The largest of these is the so-called Yukon Flats, a depressed area at the great bend of the middle Yukon, 200 miles in length and from 40 to 100 miles wide. This has an elevation of about 500 feet and, as its name implies, is a monotonous lowland. Lowlands of similar character, but of less extent, occur in the Kuskokwim, Koyukuk, Tanana, and White River valleys.

[a] Brooks, Alfred H., Reconnaissance in the Cape Nome and Norton Bay regions, Alaska, 1900: U. S. Geol. Survey, 1901, pp. 16–20.

THE ROCKY MOUNTAIN SYSTEM

The name "Rocky Mountain system" has long been applied to the easterly group of ranges of the great cordillera of western North America. This system, as has been shown, continues northwestward nearly to the Arctic Ocean, then turns almost at right angles, crosses the International Boundary in about latitude 68°, and stretches across northern Alaska, finally dying out before it reaches the Arctic Ocean.

The Rocky Mountain system of the United States is composed of several high ranges whose axes are in general parallel, and this complexity is retained to about the northern boundary of British Columbia, where the system includes a number of parallel ranges 3,000 to 4,000 feet in height.[a] North of this the Rockies of Canada are but little known, but appear to embrace highlands about 50 miles wide, which stretch northward toward the Arctic coast and, broadly speaking, form the watershed between the Yukon on the west and the Mackenzie on the east.

Where the Rocky Mountain system enters Alaska it comprises a mountainous belt over 100 miles wide, consisting of several more or less distinct ranges separated by broad, low gaps, and containing peaks 7,000 to 8,000 feet high.[b] The western extension is also little known, but appears to constitute a high, rugged mass made up of two or more ranges. These ranges have been grouped together under the name Endicott Mountains.[c]

Schrader describes them as made up of two distinct ranges separated by a less elevated though also mountainous belt. The northernmost reaches an altitude of something over 6,000 feet and the southern a little less than 5,000 feet, the two forming a rugged mountain mass about 80 miles in width. To the west the two ranges diverge, being separated by a depressed area which contains the headwaters of the Colville and Noatak rivers. The mountains rapidly decrease in altitude and appear to die out before they reach the Arctic coast.

Schrader[d] has called attention to the plateau character of the Endicott Mountain mass. Viewed from altitudes of 6,000 feet the mountains show a remarkably even sky line, suggesting that they have been carved from an ancient plateau.

ARCTIC SLOPE REGION

At the international boundary the northern face of the Rocky Mountains rises almost directly from the sea, with only a few miles of low coastal plain between it and the Arctic Ocean. To the west

[a] McConnell, R. G., Report on an exploration in the Yukon and Mackenzie basins, N. W. T. Ann. Rept. Geol. Survey of Canada, Vol. IV, 1890, pp. 8D, 9D.
[b] Turner, J. E., Ann. Rept. U. S. Coast and Geod. Survey, No. 1, 1891, p. 88.
[c] Schrader, F. C., Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904.
[d] Op. cit., p. 463.

the coast line bends northward and the mountain front retreats southward, thus widening out the coastal belt to more than 150 miles near the one hundred and fifty-sixth meridian. This province, which embraces both a plateau and a coastal plain, has here been termed the "Arctic slope region."

Schrader,[a] who has traversed this province along the valley of the Colville River, distinguishes in it the Anaktuvuk Plateau and the coastal plain. The former lies immediately adjacent to the mountain front, where it has a height of about 2,500 feet; thence it stretches northward, retaining its character as a rolling upland and sloping gently toward the Arctic for about 80 miles from the mountains, where, according to Schrader, the coastal plain begins. As he makes no mention of any sharp demarcation, it is inferred that there is a gradual transition between the two topographic forms, their difference lying in the fact that the plateau has a gently rolling surface, while the plain is absolutely flat. In genesis, however, the two types differ, for the plateau is an uplifted, eroded surface, while the coastal plain is a constructional form, largely built up of horizontal stratified sediments.

It seems likely that the whole region lying north of the Rocky Mountains has essentially this type of topography, but it is almost unexplored. At Cape Lisburne Collier[b] has found remnants of a former plateau surface at an altitude of about 1,500 to 2,000 feet, which is probably a westward extension of the Anaktuvuk Plateau.

DRAINAGE

The waters of Alaska find their way to three oceans: About a fifth of the area drains to the Pacific Ocean; the great interior region, covering nearly one-half of the entire area, is drained by rivers flowing into Bering Sea, and the rest, which comprises the northern part of Alaska, drains to the Arctic Ocean.

The Pacific drainage is carried to the sea by six important rivers, besides many minor streams. Three of these rivers, the Stikine, Taku, and Alsek, have their sources in the interior plateau region, and break through the coastal mountain belt to reach tide water. The valley of the fourth, the Chilkat, separates two of the coastal ranges. The Copper River also traverses one range of the coastal mountains, but here the Pacific Mountain system broadens out, and the headwaters of the Copper do not reach into the Plateau Province. In this drainage basin lies much of the so-called Copper River Plateau, already described. The Sushitna (another of the important rivers) has its basin entirely within the Pacific Mountain system. Its lower valley

[a] Schrader, F. C., Reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 45–46.

[b] Unpublished notes.

is an inland extension of the Cook Inlet depression, and it receives the eastern drainage of the Alaskan Range, and a part of that of the Copper River Plateau.

The Pacific seaboard has abundant precipitation, and in volume of water its streams are out of proportion to the areas which they drain. In the highlands of this province much of the precipitation is in the form of snow, which descends to the lowlands as glaciers.

Nearly all of the vast central plateau region and much of the inland slopes of its bordering ranges and area, comprising not only over half of Alaska but also a considerable part of British Northwest Territory, in British Columbia, is drained into Bering Sea. This watershed embraces a number of rivers of considerable size, emptying into Bristol Bay, the Kuskokwim drainage basin, the Yukon drainage basin, and a number of smaller streams which flow into Norton Sound.

The region roughly blocked out by the Alaskan and Aleutian ranges, the Tanana and Yukon rivers, and Bering Sea has been but little explored. The topography, as far as known, consists of rounded hills and low mountains, seldom exceeding 2,000 feet in altitude, with broad stream valleys. Two large lakes, Iliamna and Clark, about which there is but little definite information, lie just west of the Aleutian Range. These find an outlet into Bristol Bay through the Kvichak River. Several other small rivers flow into Bristol Bay, but the greater part of the region, including an area of about 50,000 square miles, drains to Bering Sea by the Kuskokwim, the second river in size in Alaska. The headwaters of the Kuskokwim are only partly explored, but are known in part to interlock with tributaries of the Tanana and Yukon rivers and in part to find source on the northwestern slope of the Alaskan Range. The lower Kuskokwim for 600 or 700 miles has a broad, flat valley, which, as it approaches Bering Sea, opens out and finally merges with the flats at the mouth of the Yukon.

The Yukon is the master stream of Alaska and the main artery of an extensive drainage system which gives access to much of the vast intermontane region. With its longest tributaries, the Lewes and Teslin, it has a length of about 2,300 miles and a catchment area of about 330,000 square miles, over half of which lies in Canada, and it is fifth in rank among the rivers of North America.

The source of the Yukon lies in British Columbia and all of its upper drainage channels trend northward and northwestward. The main river maintains this course as far as the Arctic Circle, where it makes a right-angled bend to the southwest and continues to flow in this general direction until it empties into Bering Sea. Its basin embraces an irregular area in Alaska and adjacent portions of Canadian territory, and is roughly outlined on the north, east, and northeast by the Rocky Mountain system and on the south by the Pacific Mountain system. To the southeast there are no considerable high-

lands, for there the tributaries of the Yukon, the Liard, and Stikine, interlock irregularly within the plateau region.

The chief tributaries of the Yukon are the Koyukuk, the Tanana, the Porcupine, the White, the Pelly, and the Lewes. The two latter rivers, which lie entirely in Canadian territory, unite to form the Yukon. The headwaters of the Lewes are but 25 miles from the coast at Lynn Canal. Two passes, the Chilkoot (3,100 feet) and the White (2,800 feet), break the Coast Range at the head of Lynn Canal and afford routes into the interior. This natural gateway to the Klondike gold fields was used by thousands of gold seekers during the excitement of 1897 and 1898. A railway over the White Pass now connects tide water with navigable waters on the Lewes River.

The upper tributaries of the Yukon have intrenched their valleys to a depth of about 3,000 feet in the plateau. The gradient of the river is such that this relief is decreased to about 1,500 feet at the great bend of the Yukon. Below this point the slope of the plateau and of the river seem to be about parallel, as the relief remains about the same. The Yukon proper, in its upper course, has a rather narrow valley as far as the upper end of the so-called Yukon Flats, where the walls rapidly recede. These flats continue for about 200 miles, and then the valley narrows again. Below the mouth of the Tanana the valley walls gradually recede again, and the valley finally emerges into the coastal plain.

That portion of the Yukon which is within Alaska receives three important tributaries, the Koyukuk, the Tanana, and the Porcupine rivers. The Koyukuk rises in the northern ranges of the Rocky Mountain system, flows southwestward, and reaches the Yukon about 400 miles from Bering Sea. For the greater part of its course it incises a broad valley in the Yukon Plateau.

The Tanana River has its source in a broad depression which separates the Nutzotin Mountains from the St. Elias Range. It traverses the Nutzotin Mountains through a narrow valley, and debouches on a broad, gravel-floored valley lowland through which it flows westward for about 100 miles. It then enters a narrow, canyon-like valley which continues for about 200 miles, but gradually broadens out near the junction with the Yukon.

The Porcupine, one of the larger tributaries of the Yukon, joins it at the Arctic Circle in the Yukon Flats. It heads in about latitude 65° 30′, within 75 miles of the Yukon, flows in a northeasterly direction to the front of the Rocky Rountains, then bends sharply to the southwest and continues in this direction to its mouth.

The White River rises on the northern slopes of the St. Elias Range, flows eastward for about 40 miles, nearly parallel with the range, in a broad, gravel-floored valley about 10 miles wide, which gradually narrows down to a canyon about 20 miles long. The river leaves this to

debouch on a broad valley lowland which connects with the Tanana and below enters a narrow valley which continues to its junction with the Yukon.

The Arctic Ocean drainage comprises two systems: First, the rivers flowing in a westerly direction into Kotzebue Sound; and second, those having northerly courses and emptying directly into the Arctic Ocean.

Three important rivers flow into Kotzebue Sound, viz, the Selawik, the Kobuk, and the Noatak. The headwaters of these streams lie opposite to the tributaries of the Koyukuk, flowing into the Yukon, and of the Colville, flowing to the Arctic Ocean. The axes of their valleys, which have a general parallelism, are approximately east and west. The valleys are broad and are separated by minor ranges, with altitudes of 3,000 to 4,000 feet, forming the western extension of the Rocky Mountain system.

The north Arctic drainage includes three rivers of importance, the Meade, the Chipp, and the Colville, with many of lesser size. These rivers have their sources in the mountain range to the south, which has already been described. North of the mountains their valleys are incised to a depth of 200 or 300 feet in the Anaktuvuk Plateau. Near the coast this plateau falls off to a low tundra plain covered with moss and scant grass and dotted with numerous lakes, across which the rivers and streams meander sluggishly.

OUTLINE OF THE GEOMORPHOLOGY

INTRODUCTION

The genesis of topographic forms can be determined only after a basal knowledge of the lithology, structure, and distribution of the rock masses, as well as of the succession of recent earth movement, has been acquired. As much of this province is almost unexplored and the geology of no part has been adequately studied, it is evident that the groundwork for geomorphologic studies is very incomplete. Therefore only the barest outline of the history of the development of the topography will be presented here, yet the tentative conclusions presented may be not without value, because they will serve as working hypotheses until the investigations now in progress yield more definite results.

PENEPLAINS

Of the many topographic types which occur in Alaska the peneplains are the most significant from the standpoint of geomorphology, for they afford the keys by which the recent geologic history may be deciphered. Four peneplains of considerable extent have been 'scribed: First, that recorded in the summit levels of some of the

ranges of the Pacific Mountains, from 5,000 to 8,000 feet in altitude; second, the Yukon Plateau, from 1,000 to 6,000 feet high; third, the summit level of the Endicott Mountains in northern Alaska, about 6,000 feet above the sea, and fourth, the Anaktuvuk Plateau, which slopes from 2,500 feet at the base of the mountains to 800 feet 100 miles to the north, where it appears to merge into the constructional plateau made up of late Tertiary sediments.

In the correlation of the several peneplains lies the key to the entire physiographic history of the province. The writer is well aware that in attempting correlations on the fragmentary data available he is treading on dangerous ground, for the results of surveys now in progress may overthrow any conclusion arrived at before they can appear in print. He believes himself fortunate, therefore, to be able to share the burden of responsibility with Dr. A. C. Spencer, who has already broken the ground for speculation by his very suggestive paper entitled "The Pacific Mountain system in British Columbia and Alaska,"[a] which is the first attempt at any general conclusions regarding the origin of the physical features of Alaska. What here follows is largely an exposition of Spencer's theory, but with a somewhat broader application.

It will be well to pass in brief review the facts already recited in regard to the recognized planation surfaces.

The Coast Range is an irregular aggregate of peaks and crest lines, with a general accordance of summit level, believed to be an inheritance from a former base level of erosion. In British Columbia this summit level, which is probably not far below the old peneplain, has an altitude of 8,000 to 9,000 feet, but near the head of Lynn Canal, in Alaska, this falls off to about 5,000 feet. Fifty miles to the northwest, near Cape Spencer, Gilbert[b] recognized the same surface of degradation in uplands less than 3,000 feet in height. Near the northern end of the mountains and along a part of their inland front the summit level of the Coast Range merges into the Yukon Plateau, clearly indicating the identity of the two peneplains. On the other hand, the Coast Range peneplain abuts abruptly against the southern slope of the St. Elias Range. The valleys of the Alsek and Stikine rivers, as well as those of other streams of British Columbia to the south, which lie transverse to the coastal mountains, appear to have inherited their courses from a drainage system which was developed upon the old peneplain.

A similar accordance of summit levels has been observed in the two forks of the St. Elias Range—the northern, or Nutzotin Mountains, and the southern, or Chugach Mountains. This uniformity of crest line is interpreted as a remnant of former peneplain conditions. In

[a] Bull. Geol. Soc. America, Vol. XIV, pp. 117-132.
[b] Harriman Alaska Expedition, Vol. III, p. 125.

the Chugach Mountains the summit level is about 6,000 feet, with occasional residuary peaks which rise to 8,000 feet. The Copper, like the Alsek and Stikine rivers, is believed to be an antecedent stream, which has maintained its course across the Chugach uplift.

The dissected plateau of the Chugach Mountains on the east appears to abut against the higher mountain mass of the main St. Elias Range. The same relation seems to exist between the westward extension of the summit level of the Skolai and Nutzotin mountains and the Alaskan Range, for the latter rises as a rugged mass above the level of the dissected plateau. The relation at the north base of the Nutzotin Mountains is less well known, though a study of the topographic reconnaissance maps makes it appear that here, as along the inland slope of the Coast Range, there is a transition between the summit level of the mountains and that of the Yukon Plateau. In any event, here there is no such sharp line of demarcation as that between the Yukon Plateau and the northern base of the St. Elias Mountains.[a]

The Yukon Plateau, the third and by far the most extensive of the peneplains, forms the dominant topographic feature of central Alaska. It has already been described as a great upland, broken by numerous broad drainage ways with flat-topped interstream areas which mark the surface of the former peneplain. Some of the flat-topped remnants whose summits mark the plain include smooth, unbroken areas several square miles in extent.

In general, the plateau surface slopes toward the axial line of the province as well as to the north and west. The contours of its surface mark a broad, shallow trough whose sides are formed by the two mountain systems and whose medial line slopes toward Bering Sea, or in other words, pitches toward the north and west. There are, however, many local variations from this general form, for the plateau floor is in fact a warped surface, with many minor domes and depressions.

In British Columbia the plateau stands at about 6,000 feet, but falls off to 4,500 at the international boundary and then gradually declines toward Bering Sea probably to less than 1,000 feet near the Yukon delta.

The general altitude of the plateau along the inland front of the Pacific Range is between 5,000 and 6,000 feet. It has been shown that it merges into the Coast Range summit level, abuts abruptly against the northern face of the St. Elias Range, possibly merges into the summit level of the Nutzotin Mountains, and that there is a sharp line of demarcation between it and the northern front of the Alaskan Range.

[a] It should be noted that the sharp transition between the rugged mountains of the Pacific system and the upland of the interior, which has been so often emphasized in description of Alaskan topography, is true only of the St. Elias and Alaskan ranges and along the southern part of the Coast Range.

The eastern and northern margins of the plateau are less well known. Schrader recognized it in the Koyukuk basin in northern Alaska, and believed it to be sharply differentiated from the Endicott Mountains, as he terms this part of the Rocky Mountain system, though a study of the topographic reconnaissance maps hardly bears out this view, for the plateau seems to rise gradually toward the summit of the mountains. A lower peneplain was recognized by Schrader and called the Koyukuk Plateau. The following statement by Schrader seems to find support in the contoured maps, and points toward a gradual transition between planated summits of the Endicott Mountains, the Yukon Plateau, and the Koyukuk Plateau, and hence does not accord with his conclusions:

The higher level Yukon Plateau, which also suggests a former plateau, now dissected and largely removed by erosion, lies at about 3,000 feet, but is indefinite. Its best expression occurs along the base of the mountains, where portions of nearly flat-topped ridges, rising gently northward, soon merge into the foothills of the mountains, while to the south they become lost in irregular ridges and hills, descending to the lower or Koyukuk Plateau.[a]

The highest level is preserved in uniform summits of the Endicott Mountains which stand at an altitude of about 5,000 to 6,000 feet and which, it is believed, mark a peneplain. On the north these summits fall off abruptly to a second peneplain which finds expression in the Anaktuvuk Plateau. The surface of this plateau is a gently rolling upland, which slopes from 2,500 feet at the base of the mountains and 60 miles to the north appears to merge into a constructional plateau of Tertiary (Pliocene?) sediments.

A careful analysis of the rather fragmentary data of the stratigraphic and structural geology goes to show that the Yukon, Coast Range, Endicott, and Anaktuvuk peneplains were formed during the interval between Kenai (Eocene) and Pliocene times; in other words, that they are practically of the same age. Of the Chugach peneplain there is less definite evidence, but it is certainly post-Mesozoic and pre-Pleistocene.

The correlation of the southern peneplains—the Coast Range, the Chugach, and the Yukon—has already been suggested by Spencer in the paper cited. The writer must confess to having at first maintained considerable skepticism toward this correlation. The recent topographic surveys in the headwater region of the Copper and Tanana rivers appear, however, to indicate a transition between the Chugach-Nutzotin and Yukon Plateau peneplains, and thus to lend support to Spencer's theory, as do also the stratigraphic studies, which indicate that all of the peneplains recognized in Alaska are of the same age.

[a] Reconnaissance in northern Alaska: Professional Paper U. S. Geol. Survey No. 20, 1904, p. 44.

Spencer's argument, which is based almost entirely on the topographic evidence, is summarized by him as follows:[a]

I. The interior and Yukon plateaus of British Columbia, Yukon, and Alaska have been previously recognized as uplifted peneplains, and in the Copper River region the summits of the high mountains have been described as upraised base-level surfaces. It now appears that the uniform summits which are found over the greater portion of the Pacific mountain system in the north are also representative of elevated peneplains which have suffered deep dissection.

II. The peneplains of the different portions of the coastal mountains and the inland plateaus can be correlated one with another. The antecedent nature of the rivers which cross the present coastwise barrier demonstrates the identity of the ancient erosion surfaces throughout the region outlined.

III. The Pacific province was raised after the production of the peneplain by erosion extending through Eocene (?) time, mainly through uplifts of a continental character. Regional elevation was accompanied by warping, flexure, or displacement, raising tectonic blocks which have not been effaced by subsequent erosion; but there has been no mountain building due to tangential compression.

His contention then is that the Pacific mountain system of Alaska, with the exception of the Alaskan and the highest part of the St. Elias ranges, was planated at the same time with the Yukon Plateau, and the present relief is largely due to subsequent differential uplift.

Schrader showed that the summits of the Endicott Mountains of northern Alaska also mark a planation surface which he believes to be of the same age as the Chugach peneplain, but older than the Yukon peneplain. In other words, Spencer recognizes but one extensive peneplain in the portion of the Alaskan cordillera considered by him, while Schrader believes there were two distinct surfaces. One objection to Schrader's interpretation of these features lies in the improbability that any remnants of an older peneplain should be preserved during the long period of erosion while the second was being cut, for it must be remembered that the second erosion level has been traced through an area 500 by 2,000 miles in extent. If there were two peneplains it would be expected that the older would be preserved in the harder rocks and the younger recorded in the softer strata, but nothing of this kind has been noted. Another objection to the dual peneplain theory lies in the fact that the older plain must have been pre-Eocene in age, and would have been distorted, if not entirely destroyed, by the very marked epoch of deformation which is known to have taken place throughout Alaska since Eocene times. It seems at least improbable that any pre-Eocene land surface should be still preserved.

A logical extension of Spencer's correlation of the peneplains in the Chugach Mountains, Coast Range, and Yukon Plateau would include the peneplain of the Endicott Mountains, and even that of the Anaktuvuk Plateau. The little that is known of the geology of the Arctic

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[a] Bull. Geol. Soc. America, Vol. XIV, p. 132.

slope region points toward such a correlation, though it is evident that it is impossible now to give it any more weight than that of a working hypothesis. If the Anaktuvuk and Endicott peneplains are identical in age, there must have been a sharp flexure or fault at the northern front of the mountains during, or subsequent to, the uplift which brought the plateaus in their present positions.

RECENT GEOLOGIC HISTORY

INTRODUCTION

In the foregoing pages the topography has been described and the peneplains have been discussed. It remains to present a summary of the recent geologic history and thus outline the development of the existing land forms, as far as the evidence at hand will permit. Briefly stated, the topography is believed to be the result of the following succession of events which, for the sake of brevity, will be presented categorically:

First. Some time in late Jurassic or early Cretaceous time there was a dynamic revolution which seems to have affected the entire province, and this can be conveniently taken as the beginning of recent geologic history. The close of the disturbance saw much of Alaska above the sea and inaugurated a long cycle of degradation. Volcanic vents opened in the Alaskan Peninsula and in the Wrangell Mountains.

Second. A partial submergence followed during later Cretaceous times, and the sea invaded the Lower Yukon and Kuskokwim regions, the Arctic slope province, and probably a part of the Pacific littoral. This submergence in certain districts continued well into the Eocene. The Eocene deposition was in part in open ocean, in part in embayments, and in part probably in lakes.

Third. Sedimentation was terminated late in the Eocene or early in the Miocene by an uplift accompanied by widespread though not intensive deformation. After this disturbance Alaska had about its present shore line, and its two mountain systems were probably marked by areas of considerable relief. A long period of relative stability followed, during which a large part of the province was reduced to a peneplain. At the close of this cycle there was probably left along the present St. Elias Range some kind of mountain barrier which was bisected by the ancestor of the Alsek River. Volcanism continued in the Wrangell and Alaskan Peninsula regions.

Fourth. In late Pliocene or early Pleistocene times the region was again elevated by an uplift, differential and probably intermittent, to about its present altitude, and the previously developed peneplain was deeply dissected. The Yukon drainage system was developed in part along lines determined by the previous base-leveled conditions. The

Alsek, Stikine, and other southward-flowing rivers maintained their courses across the coastal mountain barriers, which had been uplifted to a greater altitude than the interior province. At the same time the Noatak and Kobuk valleys were incised structures in a general way following bed rock. Volcanism continued in the Wrangell and Aleutian mountains.

Fifth. The elevated tracts throughout the province became the breeding grounds of glaciers which moved down the slopes, filled up the valleys, and in many instances stretched out into the lowlands far beyond the mountain slopes. In southeastern Alaska the great Cordilleran glacier scoured out the preexisting valleys.

The ice subsequently retreated and the accompanying floods filled the valleys and lowlands with extensive alluvial deposits in which were mingled Pleistocene organisms. As the waters became less burdened with sediments, they gradually began to erode and entrench the extensive mantle of overwash, an action which is still going on.

There is evidence that during Pleistocene there were many local elevations and depressions, and some of these have affected the drainage systems.

CONDITIONS ANTERIOR TO UPPER CRETACEOUS TIMES

It is known that deformation and metamorphism took place in recurrent epochs during Paleozoic and early Mesozoic times, but these influenced the development of the present land forms only so far as they determined lines of weakness along which erosion was subsequently active. The last of these disturbances of sufficient intensity to produce any considerable metamorphism affected rocks of late Jurassic or early Cretaceous age.[a] This movement of the earth's crust seems to have been far reaching, for its influence has been observed in the Lower Cretaceous terranes throughout Alaska. Its intensity varied greatly, for in one locality, as on the upper Yukon, the strata of this age were closely folded and more or less metamorphosed, while in another, in the Copper River Basin,[b] they were only indurated, uplifted, and slightly deformed. This epoch of disturbance will be chosen as the starting point of the discussion of the recent history of the region, for it seems to have been the first to have directly influenced the development of the present topography.

At the close of this disturbance much of the province was uplifted above the sea, and erosion began on the newly made land surface. During this period of degradation volcanism first became active in the Copper River[c] region since Paleozoic times and probably also was revived in the Aleutian Range.

[a] The stratigraphic position of the Aucella-bearing beds of Alaska is still in some doubt, but here they are classed as Lower Cretaceous.

[b] Geology and mineral resources of a part of the Copper River district, p. 51.

[c] Op. cit., p. 51.

There is no measure of the duration of this cycle of erosion, but in the Copper River basin, at least, it seems to have continued a sufficient length of time to reduce the land nearly to base level. It seems probable that some parts of the province remained exposed to atmospheric agencies much longer than others, for in some places the Upper Cretaceous rests on the Lower Cretaceous; in others the former is absent and the latter are directly overlain by Eocene beds. The evidence of this deformation and subsequent erosion is found in the marked unconformity between the Lower Cretaceous and overlying Mesozoic or Eocene sediments which have been noted throughout the province.

LATE CRETACEOUS AND EARLY EOCENE DEPOSITION

A gradual submergence of a part of the province terminated the period of erosion and inaugurated sedimentation. In the lower Yukon and Kuskokwim valleys and in the Arctic slope province the deposition began during later Cretaceous times and continued without interruption through a part of the Eocene. The fragmentary nature of the evidence[a] makes it impossible to determine what part of Alaska was submerged during this epoch, but it is probable that the transgression of the sea in later Cretaceous time was gradual from the southwest and extended as far inland as the mouth of the Porcupine. Dawson[b] has suggested that during Laramie time (later Cretaceous) much of the lower Yukon basin was occupied by the sea, and the stratigraphic studies of Collier[c] would confirm this in part at least. He found marine Upper Cretaceous beds on the lower Yukon, succeeded by Eocene beds with conformable relations. As the latter are chiefly fresh-water deposits of a coarse character, such as conglomerate and sandstone, it is fair to presume that they were laid down in embayments or estuaries. These Eocene beds are found on the Yukon near the International Boundary, which makes it probable that deposition was going on throughout the Yukon Valley below. It is possible, however, that the fresh-water beds are in part of lacustrine origin and there is no definite evidence that the invasion of the Tertiary sea extended above the mouth of the Tanana. Indurated sandstones of Upper Cretaceous or Eocene age were observed by the writer as far east as the head of the Cantwell, a southern tributary of the Tanana. The surveys in the Copper River region have failed to reveal any Upper Cretaceous sediments, but some Eocene beds have been found, and the Wrangell volcanoes had at this time long been active.

[a] The Upper Cretaceous and Tertiary succession in Alaska is as yet imperfectly known.

[b] The late physiographical geology of the Rocky Mountain region: Trans. Royal Soc. Canada, 1890.

[c] Collier, Arthur J., The coal resources of the Yukon: Bull. U. S. Geol. Survey No. 218.

Schrader[a] has described marine Upper Cretaceous fossils in a sandstone-shale series overlain by Eocene beds north of the Rocky Mountains, and has presented less definite evidence of the occurrence of beds at this horizon on the south slope of the mountains. His results suggest at least that these deposits may have been laid down in seas separated by a barrier. Some Upper Cretaceous sediments have been found in the Pacific littoral, and this district must have been in part submerged during this cycle.

The facts indicate that deposition was going on in western Alaska, probably in part in what was open ocean, in part in an embayment, and in part in lakes, during late Cretaceous and early Eocene times. During this long period there were probably many oscillations of the land mass, which brought about repeated changes of shore line. It seems probable that there was then a land area in the present region of the Rocky Mountains and another east of the one hundred and forty-first meridian previous to the initiation of uplift after early Eocene deposition.

UPLIFT AND PLANATION (LATE EOCENE OR MIOCENE)

About the close of the Eocene there was a gradual uplift throughout the province which, though of an orographic character, was accompanied by considerable local disturbance of the Eocene beds.

The date of this uplift, though in doubt, is probably late Eocene or early Miocene times. Dawson[b] refers this orogenic movement to the Eocene, but if the identification of the upper Eocene beds in the Lower Yukon basin, deformed at this period, is trustworthy it would show that the dynamic revolution took place somewhat later. Further evidence on this point is afforded by some unconsolidated beds that have been found on the Yukon below the mouth of the Tanana, which are practically undisturbed and must have been laid down since this period of deformation. As these are Miocene or Pliocene, they go to prove that the movements were pre-Pliocene and possibly pre-Miocene, and as this is in general accord with the other evidence, they can be regarded as marking the close of the Eocene.

It seems probable that this elevation affected all of Alaska and exposed a land mass of considerable relief, with a shore line not essentially different from that which now exists.

Degradation began on the exposed land mass, and, during a long period of stability which followed, an area including hundreds of thousands of square miles was reduced to a peneplain. The limits of this planation surface have been discussed in full, but it must be understood that, whatever correlations of the higher plains may be made, there can be no doubt that the Yukon Plateau, the British Columbia Plateau,

[a] Schrader, F. C., A reconnaissance in northern Alaska: Professional Paper U. S. Geol. Survey No. 20, pp. 79-83.

[b] Geological record in the Rocky Mountain region of Canada: Bull. Geol. Soc. Am., Vol. XII, p. 79.

and the Coast Range were base-leveled during this epoch. The evidence for the contemporaneous origin of the Chugach, Endicott, and Anaktuvuk with the Yukon peneplain has been presented, and for the purposes of this exposition this will be accepted as proved.

Whatever, then, may have been the history of the bordering mountain systems, a large part of the central region at least was reduced to a peneplain during the epoch of erosion which followed the late or post-Eocene deformation. The resulting plain sloped gently toward the sea, and occupied the larger part of what is now the Yukon basin. Here and there the featureless lowland was broken by a mountain or peak which rose above the general level.

The ancestor of the present Yukon was among the rivers which meandered across this lowland with the tortuous courses characteristic of base-leveled conditions, and probably had very much its present position from the junction of the Pelly and Lewes to the sea. But only a part of the present drainage of the Yukon flowed to Bering Sea, for some found outlet to the Pacific by a river which followed the course of the present Alsek. This stream appears to have bisected a low mountain barrier which occupied the present position of the St. Elias Range. According to Spencer, another river reached the sea along the valley of the present Copper. As the planated surface extended across the present Coast Range, there was then no coastal barrier. The drainage was carried to the Pacific by the Taku, Stikine, and other rivers, many of which during the subsequent uplift, like the Alsek, maintained their valleys to the Pacific across a gradually rising barrier. In northern Alaska the peneplain swept across the present Rocky Mountains and stretched northward to the Arctic Ocean, where the eroded plain was extended seaward by the constructional surface formed of late Tertiary sediments.

At the close of this extensive period of denudation central Alaska had probably the contour of a broad, shallow trough, whose sides sloped gently from the borders to an axial line that corresponded in a general way with the present Yukon Valley. A broad, flat watershed probably separated the western trough from the northward-flowing Arctic drainage, and another similar divide appears to have intervened between the Bering and Pacific drainage somewhere in what is now northern British Columbia.

DIFFERENTIAL ELEVATION AND EROSION

Elevation of the entire land mass closed the long period of stability and extensive planation. The trough-like form of central Alaska was emphasized by the uplift, which was greater along the margins than within the trough, forming a broad, shallow depression between two lines of height, a depression which corresponded in a general way with the position of the present Yukon Valley.

The fact that the several rivers which flowed into the Pacific across that part of the peneplain which is now marked by the Coast Range maintained their courses shows that the uplift was very gradual. The tortuous channels of the Yukon Valley in the Ramparts and above the Flats are interpreted as the incised meanders of the stream during previous base-leveled conditions, and also indicate slow elevation. As elevation continued, river and stream valleys were incised and a drainage system was developed which to a great extent followed preexisting lines. It has been indicated that the course of the Yukon was not very different from what it is now. Its great southwest bend appears to have been consequent upon the contour of the uplifted area, a feature partly inherited from the configuration of the lowland areas and in part induced by differential uplift.

It seems well established that part of the southern drainage of the upper Yukon then found outlet to the Alsek, whose basin formerly included a valley now represented by a series of broad northwest-southeast depressions lying southeast of the one hundred and forty-first meridian and south of the Yukon River. These indicate a well-developed drainage system tributary to the Alsek, which must have included the upper part of White and Tanana valleys, as well as several of the southern tributaries of the Lewes and upper Yukon rivers. It seems probable that the broad northeast-southwest depressions extending southward into British Columbia have had a similar history, and mark the position of a drainage system tributary to rivers emptying into the Pacific through transverse valleys.

The differential uplift was greatest along the margins of the province, and these differences in places brought about sharp flexures or possibly faults. In British Columbia, for example, there is a difference of several thousand feet in the summit level of the Coast Range and of the Yukon Plateau. This flexure or fault finds topographic expression in the scarp which the Coast Range presents toward the plateau.

If the correlations of peneplains here suggested be accepted, it may be well to consider many similar examples in Alaska, of which the most striking is the northward-facing escarpment of the Rocky Mountains. Here the mountains descend abruptly from an altitude of about 5,000 feet to the Anaktuvuk Plateau (2,500 feet). Several movements may have taken place along the same lines, but it seems probable that the escarpments are in a large measure due to the differential character of the initial uplift.

Attention has been directed to irregularities of the surface of the Yukon Plateau. These may be due in part to irregularities of the initial elevation, or they may be accounted for by subsequent deformation of the peneplain. Stratigraphic evidence of recent deformation is found in the Pleistocene deposits, which in some places show broad plications. Of greater import is the evidence of extensive uplift and

probably fracture along the western front of the St. Elias Range, where Russell[a] found Pleistocene fossils in unconsolidated beds 5,000 feet above sea level.

There is also physiographic evidence of recent minor deformation in the plateau region, and in the Seward Peninsula. Near Rampart, on the Yukon, the plateau surface shows a marked doming, and this is believed to have caused the erosion of the broad basin above, known as the Yukon Flats. It appears that there was a local base level at this point during the period while the Yukon was channeling out its valley through the uplift athwart its course. Similar local domings may account for some of the other lowlands and even for certain lakes in Alaska and adjacent portions of Canada. Evidence of recent deformations in the Seward Peninsula is found in the character of the coast line and in the warped marine benches which have been fully discussed elsewhere.[b]

The Aleutian Range and the Wrangell Mountains have been ascribed to extravasations of volcanic material which took place after the last stage of deformation and probably during and subsequent to the abrasion of the peneplain. The exact date of the beginning of the volcanic activity has not been determined, but it is safe to say that it was post-Eocene, and it has continued up to the present time. In these mountains erosion has lagged far behind upbuilding, hence their present high relief.

The uplift was probably not a single movement, but the total effect is the result of a number of elevations interrupted by periods of stability. Nor was the movement necessarily all upward, for the land may have oscillated, but the algebraic sum of these disturbances was elevation. These orographic movements have left topographic records, but these are not yet sufficiently well known to be correlated and will not here be discussed.

INFLUENCE OF GLACIAL EPOCH ON TOPOGRAPHY

Glaciation in the larger part of Alaska was of limited extent and except in the Panhandle had no very marked effect upon the topography, but a large amount of material was transported as overwash deposits beyond the limits of the ice.

The Cordilleran glacier, uniting with the ice from the Coast and St. Elias ranges, effectually blocked the channels of the southward-flowing streams, such as the Alsek, and their drainage was for a time diverted to the Yukon. It has been shown elsewhere[c] that probably one of

[a] Russell, I. C., Expedition to Mount St. Elias: Nat. Geog. Soc. Mag., Vol. III, 1891, pp. 170–175.

[b] Brooks, Alfred H., A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900: U. S. Geol. Survey, 1901, pp. 56–62. Collier, Arthur J., A reconnaissance of the northwestern portion of the Seward Peninsula, Alaska: Professional Papers U. S. Geol. Survey No. 2, 1902, pp. 34–42.

[c] Brooks, Alfred H., Reconnaissance from Pyramid Harbor to Eagle City: Twenty-first Ann. Rept. U. S. Geol. Survey, Part II, 1900, p. 354.

the effects of this ice blockade was thus to divert some of the former drainage of the Alsek to the Tanana and White rivers. This same Cordilleran glacier traversed the valleys that lie transverse to the Coast Range and, uniting with the local glaciers, covered the greater part of southeastern Alaska and the adjacent islands. It has been indicated that probably much of the erosion of the fiords and channels of this coast may have been brought about by ice erosion when the land stood at about its present level. According to Mr. Gilbert[a] the apparently drowned shore line is due rather to glacial erosion than to an extensive depression, and the glacial scouring followed the channels of a pre-Glacial drainage system.

Other districts afford nothing to compare with southeastern Alaska for extent of glacial erosion, except possibly in the irregularities of shore line of Prince William Sound. In all the higher ranges, where there has been ice accumulation, cirques and U-shaped valleys are typical topographic forms, but these are comparatively slight modifications of a preexistent topography.

The overwash deposits of the Glacial epoch embrace the silts which are found in the entire length of the Yukon Valley, the gravel plateaus in the upper Kuskokwim basin and on Cook Inlet, and many deposits of lesser extent. After the ice disappeared the streams gradually lost their burden of glacial débris and soon began actively cutting their aggraded valleys, so that the glacial deposits are exposed along the river bluffs.

In previous reports the author had advocated the view of a marked post-Glacial uplift, but he is now inclined to interpret the terraces as the result of changes in the erosive powers of the streams.[b] It is impossible, however, to deny that some uplift has taken place since the retreat of the ice, for even in southeastern Alaska, where the topography suggests depression, marine benches have been found 200 to 600 feet above the present sea level, and in other districts the evidence all points toward elevation. It seems, then, probable that there has been a very recent upward movement relative to sea level throughout the interior and in northern Alaska. Of this there is undeniable evidence in the terraces and marine benches along the shores of both the Arctic Ocean and the northern Bering Sea. The retreat of the several ice sheets and the deposition and incision of their overwash material left the topography essentially in its present form.

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[a] Gilbert, G. K., Alaska, Vol. III, Glaciers and Glaciation: Harriman Alaska Expedition 1904, pp. 134–139.

[b] Compare Schrader and Spencer, The Geology, etc., of the Copper River District: U. S. Geol. Survey, 1901, p. 80.

GRUNDZÜGE DES GEBIRGSBAUS VON MITTELAMERIKA

Von KARL SAPPER, Tübingen.

Obgleich Mittelamerika, die vom Isthmus von Tehuantepec bis zum Isthmus von Panama sich hinziehende Landbrücke zwischen Nord- und Südamerika ein Gebiet vom höchsten wissenschaftlichen und praktischen Interesse ist, gehört es doch gegenwärtig noch zu den ungenügend erforschten Ländergebieten des Erdballs, weshalb ich auch nur einige Andeutungen über den geologischen Aufbau zu geben vermag.[a]

[a] Die *wichtigsten* Nachrichten über die Geologie Mittelamerikas sind in folgenden Schriften zu finden:
1841. John L. Stephens: Incidents of Travel in Central America, Chiapas, and Yucatan. New York. 2 Bde.
1847. R. G. Dunlop: Travels in Central America. London.
1852. E. G. Squier: Nicaragua, Its People and Monuments. New York.—Derselbe, 1855: Notes on Central America.
1856. C. von Scherzer: Mitteilungen in Sitz.-Ber. Wiener Akademie, Math.-naturw. Cl.
1856. Carl Hoffmann in Bonplandia.
1856. Manross, Chiriqui Improvement Co. Geological Report. New York.
1857–58. F. Fröbel: Aus America. Leipzig. 2 Bde.
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I.

Am Aufbau Mittelamerikas beteiligen sich archäische, paläozoische, mesozoische und känozoische Schichtgesteine neben verschiedenalterigen Eruptivgesteinen in wechselndem Verhältniss.

Gneisse, Glimmerschiefer und Phyllite, gelegentlich mit eingeschalteten krystallinen Kalksteinen, Hornblendeschiefern, Chlorit-Talkschiefern, etc., sind in grosser Ausdehnung im nördlichen Nicaragua, in Honduras, in Mittelguatemala und im mittelamerikanischen Anteil des mexicanischen Staats Oaxaca nachgewiesen, in kleinerer Ausdehnung auch in Britisch Honduras und in Chiapas. Für Costarica und die Republik Panama wird das Vorkommen krystallinischer Schiefer an einzelnen Stellen berichtet; aber es ist zweifelhaft, ob es sich hier um archäische Gesteine handelt. Die in der Provinz Veragua beobachteten Glimmerschiefer hält O. Hershey für tertiäre, durch Contaktmetamorphose umgestaltete Ablagerungen.

Paläozoische Schichten (und zwar *Carbon*) sind in ansehnlicher Ausdehnung nachgewiesen im südlichen Britisch Honduras, in Mittelguatemala und im östlichen Chiapas. Im nördlichen Nicaragua und im südlichen Honduras kommen alte Thonschiefer, Sericitschiefer, Quarzite, Kalksteine, etc., vor; ihr Alter lässt sich aber wegen Mangels an Versteinerungen nicht feststellen. Mierisch nimmt für die nicaraguanischen Gesteine dieser Art *devonisches* Alter an.

Mesozoische Ablagerungen sind in Chiapas, Guatemala, Britisch- und Spanisch-Honduras in grosser, in Salvador, Nordnicaragua und Costarica in geringer Ausbreitung nachgewiesen. (In der Republik Panama scheinen sie zu fehlen: die Ablagerungen, die Hill auf dem Isthmus, Hershey in Veragua für cretaceisch angesprochen haben, sind nach neueren Untersuchungen—Douvillé, Bertrand und Zürcher—dem

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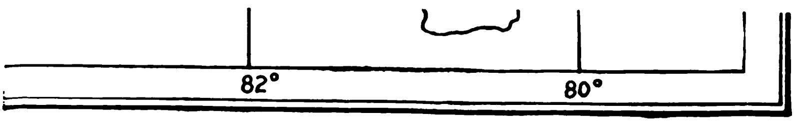
82°
80°

Tertiär zuzuweisen. Das Alter der mesozoischen Schichten ist nur teilweise genauer bekannt; *mittlere Kreide* in Honduras, *obere Kreide* in Chiapas, Guatemala, Britisch Honduras, im Nordwesten der Republik Honduras, im centralen Costarica. Von ausgedehnten Schichtcomplexen (Todos Santos-Schichten im mittleren Chiapas und Guatemala; Metapan-Schichten im südlichen Guatemala und Honduras, sowie in Salvador; Mesozoicum in Nordnicaragua) weiss man das Alter nicht genau. Newberry hat nach pflanzlichen Versteinerungen aus der Gegend von S. Juancito die Tegucigalpa (=Metapan)-Schichten der oberen Trias zugeschrieben.

Känozoische Ablagerungen: *Eocän*, *Oligocän* und *Miocän* sind in allen Gebirgsländern Mittelamerikas, fehlen aber der Halbinsel Yucatan, die aus *pliocänen* und *pleistocänen* Kalksteinen und Mergeln besteht. Pliocäne und quartäre Bildungen bedecken in einzelnen Küstengebieten, sowie in manchen Mulden des Binnenlandes namhafte Räume.

Alte Eruptivgesteine (*normaler Granit*, *Hornblendegranit*, *Syenit*, *Gabbro*, *Diorit*) sind in Chiapas, Guatemala, Britisch- und Spanisch-Honduras, Nordsalvador, Nordnicaragua und Panamá nachgewiesen. Das hohe, aber freilich vielfach erst nachcarbonische Alter dieser Eruptivgesteine ist für die meisten Stellen des nördlichen Mittelamerika unbezweifelt. Die Diorite von Nordsalvador und Nordchiapas sind nachcretaceisch. Für die Granite und Syenite Costaricas und Panamás glaubt R. T. Hill ein jugendliches (tertiäres) Alter annehmen zu dürfen, hat aber bisher seine Meinung nicht mit beweiskräftigen Grunden belegt.

Serpentine spielen im Aufbau von Chiapas und Guatemala eine grosse Rolle, kommen aber in Britisch- und Spanisch-Honduras nur noch vereinzelt, im südlichen Mittelamerika gar nicht mehr vor. Das Alter der Serpentine ist nur an wenigen Stellen Guatemalas genauer zu bestimmen (nachcretaceisch); für die meisten Vorkommen ist es unbekannt.

Jüngere Eruptivgesteine (*Porphyre* und *Melaphyre*, ferner *Rhyolite*, *Dacite*, *Andesite* und *Basalte*) sind in allen Gebirgsländern Mittelamerikas in Form von Gängen, Decken und Rücken viel verbreitet; auch Tuffe dieser Gesteine sind in grosser Ausdehnung vorhanden. Das Alter der einzelnen Gebilde ist sehr verschieden, in vielen Fällen aber noch nicht genauer bestimmt. Eruptivgesteine fehlen in den jungen Flachländern des nördlichen Mittelamerika vollkommen: Yucatan, nördliches Britisch-Honduras, Peten, Tabasco, Ost-Veracruz.

II.

Die pliocänen und quartären Bildungen sind horizontal gelagert oder zeigen nur geringfügige, sehr flache Faltung und Schichtenaufrichtung, dagegen in manchen Fällen doch nennenswerte verticale

Verschiebungen, so im südöstlichen Yucatan, wo Staffelbrüche vom centralen Plateau zum Caraibischen Meere hinunterleiten. Das Alter der den Andesiten des Hochlandes von Chiapas aufruhenden Tertiärschichten von Chamula ist leider nicht genau genug bestimmt, um Schlüsse über die Zeit der letzten grossen Niveauverschiebungen in Mittelamerika zu gestatten. Jugendliche Niveauänderungen hat C. W. Hayes überzeugend für das Gebiet der Nicaragua-Senke nachgewiesen; Hershey's weittragende Schlüsse über Landbewegungen in Veragua erscheinen dagegen nicht hinreichend begründet.

Alle älteren Gesteine (vom Miocän an) haben in Mittelamerika starke Lagenveränderungen durchmachen müssen, die sich teils in Faltungen und Flexuren, teils in Verwerfungen, teils in einer Combination der verschiedenen Dislocationsarten äusserten. Im Allgemeinen wiegt im gebirgigen Mittelamerika die Faltung vor, in Chiapas aber herrscht die Verticalverschiebung längs Verwerfungen, was natürlich auch in der Oberflächengestaltung des Gebiets zum Vorschein kommt. Eine Reihe von Oberflächenformen Mittelamerikas ist aber auf eruptive Ausflussmassen und vulkanische Aufschüttung zurückzuführen.

Im allgemeinen zeigen die älteren Gesteine auch stärkere und häufigere Dislocationen. Im Bereich der krystallinen Schiefer ist der höchste Grad der Störungen erreicht. *Drei Hauptdislocationsepochen* haben sich bisher in Mittelamerika feststellen lassen: Die erste *nach dem Archaicum*, die zweite *nach dem Carbon*, die dritte nach dem *Obermiocän*. Diesen Hauptdislocationsepochen mögen auch die Haupt*eruptionsepochen* entsprechen. Beweise für das gemeinsame Auftreten beider Ereignisse sind jedoch nur für die 2. und 3. Epoche zu erbringen, und auch hier nicht in genügendem Masse.

Die weitaus vorwiegende Störungsrichtung, sowohl in Faltungen, als in Verwerfungslinien sich aussprechend, ist ungefähr ostwestlich "*mittelamerikanische Streichrichtung*" (Sapper). In einigen wenigen Fällen ist auch nordsüdliche Streichrichtung beobachtet worden ("*andines Streichen*" Hershey's) und zwar von Hershey auf der Halbinsel Azuero und von Mierisch im nordöstlichen Nicaragua. Auch ich habe im nördlichen Nicaragua, sowie nahe der grossen hondurenischen Quersenke (zwischen Golf von Fonseca und Puerto Cortez) ziemlich häufig nahezu nordsüdliches Streichen festgestellt; diese letztere Erscheinung dürfte aber eher auf locale Querfaltung oder sonstige quergerichtete Dislocation zurückzuführen sein, als auf das Durchsetzen einer fremdartigen Gebirgsrichtung.

Das mittelamerikanische Streichen zeigt insofern eine wesentliche Ablenkung von der reinen Ostwestrichtung, als sich fast bei allen Gebirgsgliedern eine südwärts vorspringende Curve (Convexität) beobachten lässt. Die Gebirge mit mittelamerikanischem Streichen teilen sich in zwei getrennte, zwar gleichgerichtete, aber durch die verschiedene Grösse des Krümmungsradius von einander abweichende

Gebirgssysteme, die miteinander in Verbindung stehen durch das Querstück des aus jungeruptiven Decken und zugehörigen Tuffen bestehenden Hochlands von Mittelnicaragua.

Das *südliche "costaricanische" Gebirgssystem* beginnt am Isthmus von Panama und klingt in der Landenge zwischen der Südsee und den nicaraguanischen Seen aus; der Zusammenhang mit dem entgegengesetzt gekrümmten, geologisch höchst ungenügend bekannten Gebirgsbogen der Sierra de Chepo ist zur Zeit noch nicht klar gestellt. Obgleich das Gebirgssystem des südlichen Mittelamerika bei oberflächlicher Betrachtung sich als ein einheitlicher Gebirgsbogen mit mehreren Parallelketten darzustellen scheint, so erkennt man bei näherem Studium doch, dass hier zwei Gebirgsbogen von ähnlichen Krümmungsverhältnissen vorliegen, deren Enden im Hochland von Costarica durch einen Zwischenraum von etwa 25 Km. Breite getrennt bleiben. An eben dieser Stelle bemerkt man das leider ganz ungenügend bekannte etwa ostwestlich streichende Gebirge Escasú-Turúbales mit einer südlichen Parallelkette. Es liegt nahe zu vermuten, dass dieses fremdartige, vermutlich ältere Gebirgsstück die Ursache für die Zweiteilung des südlichen Gebirgssystems in einen nordcostaricanischen Bogen und einen costaricanisch-panameñischen Hauptbogen bei der Entstehung durch südwärtsgerichteten Schub geworden sei.

Das *nördliche Gebirgssystem* Mittelamerikas besitzt wesentlich grössere Breiten- und Längenerstreckung, als das südliche. Oberflächlich betrachtet erscheint auch das nördliche Gebirgssystem, das man nach seinem Hauptbestandteil als "*guatemaltekisches*" bezeichnen könnte, als ein einfacher flachgekrümmter Bogen, der im Westen an den geologisch deutlich hervortretenden, aber topographisch vielleicht nicht überall klar characterisierten Gebirgsbogen der archäischen Küstencordillere Südmexicos (die Sierra Cimaltepec von Felix und Leuk[a]) anstösst und mit ihm eine guirlandenartige Aneinanderkettung zeigt, wohl ähnlich den Gebirgskettungen Ostasiens, die F. von Richthofen[b] neuerdings eingehend beschrieben hat. Im Osten schneidet das caraibische Meer das guatemaltekische System ab. Wenn in den grossen Antillen wieder gleichgerichtete und wohl auch gleichartige Gebirgssysteme auftreten, so ist man nach dem heutigen Stand unserer Kenntniss nicht berechtigt, dieselben als unmittelbare Fortsetzungen des guatemaltekischen Gebirgssystems zu betrachten; es erscheint vielmehr wahrscheinlich, dass sie zwar durch ähnliche Ursachen, vielleicht auch in derselben Epoche, gebildet worden sind, wie die mittelamerikanischen Gebirgsbogen, dass aber ihr orogenetisches Centrum, der Herd der gebirgsbildenden Bewegung, völlig

[a] Übersicht über die geologischen Verhältnisse des mexicanischen Staates Oaxaca. Leipzig, 1893. S. 307.

[b] Geomorphologische Studien aus Ostasien: Sitz.-Ber. K. Akad. Wiss. Berlin, Physik.-Math. Cl., 1901-1903.

verschieden von dem des guatemaltekischen Systems ist und wesentlich weiter östlich zu suchen ist, als jenes. Es ist sogar wahrscheinlich, dass auch das guatemaltekische Gebirgssystem (gleich dem costaricanischen) kein einheitliches orogenetisches Centrum besitzt, denn der Gebirgsbogen des nördlichen Mittelamerika zeigt eine doppelte Knickung, so dass er in leichtem Grad guirlandenhaft wird. Die erste Störung der einfachen Bogenform findet sich an der grossen Quersenke von Honduras, die zweite in der Gegend, wo der Rio Chixoy die paläo- und mesozoischen Gebirgsketten Guatemalas durchbricht. Irgend welche Anzeichen eines Widerlagers fehlen hier wie dort; man kann sich aber die Knickung auch so entstanden denken, dass gleichzeitig von zwei verschiedenen orogenetischen Centren aus im gleichen Sinn Tangentialschub sich geltend machte und die Bogen sich nun an der Mittelzone zwischen den beiderseitigen Schubwirkungen gegenseitig stauten. Beachtenswert ist übrigens, dass bei der guatemaltekischen Knickung der Bogenform die ältere archaische Centralkette nicht mitbetroffen worden ist. Als weitere Anomalien wären zu erwähnen: auf hondureñischem Boden die flache Krümmung der nördlichen Gebirgsketten von Osthonduras, dagegen die energische Nordostrichtung des hondureñisch-nicaraguanischen Grenzgebirges; im guatemaltekischen Gebiet die flachere Krümmung des paläozoischen Gebirgsbogens im Vergleich zu seinen nördlichen und südlichen Nachbarketten. Alle diese Anomalien deuten darauf hin, dass verschiedene orogenetische Centren für einzelne Teile des nördlichen Gebirgssystems angenommen werden müssen und dass sie auch in verschiedenen Epochen verschiedene Lagen einnahmen; die gleichartige Krümmung spricht aber dafür, dass die Lage der orogenetischen Centren stets im Norden des Systems sich befunden hat, womit wahrscheinlich wird, dass die gebirgsbildenden Ursachen und Vorgänge während der verschiedenen Bildungsepochen gleichartig gewesen seien.

Bei der ungenügenden geologischen und topographischen Kenntniss Mittelamerikas ist eine genauere Schilderung des Gebirgsbaus nicht möglich und es muss fraglich bleiben, ob das nördliche Gebirgssytem ursprünglich symmetrisch gebaut war und eine wesentlich grössere Breitenerstreckung besass, als gegenwärtig; es wäre denkbar, dass der Gebirgszug Escasú-Turúbales (die einzige Gegend des südlichen Mittelamerika, wo Kreide nachgewiesen ist) der Überrest einer weit vorgeschobenen Parallelkette des guatemaltekischen Gebirgssystems wäre.

Störungslinien besonderer Art, die unabhängig von der mittelamerikanischen Streichrichtung sind, werden durch die reihenförmig angeordneten jugendlichen *Vulkane* angedeutet. Die wichtigsten Vulkane des *nördlichen Gebiets* (Guatemala bis Nicaragua) sind auf einigen wenigen, ungefähr gleich (WNW.-ESE.) gerichteten Reihen angeordnet. Diese sprungweise gegen einander verschobenen Reihen

dürften den Verlauf von Bruchlinien der Erdkruste andeuten, die durch das Absinken des Südseebeckens entstanden wären (disjunctive Dislocationen im Sinne F. von Richthofens). Die Längsvulkanreihen des nördlichen Mittelamerika, von denen einige kurze Querreihen abzweigen, liegen sämmtlich südlich von nahezu parallel gerichteten jungeruptiven Gebirgsrücken, die ihre Entstehung einer ähnlichen, aber früher und intensiver wirkenden Ursache verdanken mögen.

Im südlichen Mittelamerika ruht die Mehrzahl der Vulkane dem Kamm des nordcostaricanischen Bogens auf; die Ursache für das abweichende Verhalten der costaricanischen Vulkanreihe gegenüber dem nördlichen Vulkansystem darf wohl darin gesucht werden, dass hier im Süden des jungeruptiven Gebirgsrückens noch Gebirgsmassen (Nicoya) vorhanden sind, die einen Gegendruck auf das betreffende Gebiet ausübten und daher eine Verschiebung der Lage der Eruptionslinie nicht gestatteten. Der einsame Chiriqui-Vulcan ruht der Südabdachung des Hauptgebirges auf, ebenso wie die Tuffreste früherer Eruptionscentren, deren Lage sich jetzt im einzelnen zumeist nicht mehr nachweisen lassen wird. Es scheinen sich demnach im südlichen Mittelamerika die Eruptionslinien seit der stärkeren Tätigkeit im Tertiär nicht wesentlich verschoben zu haben.

Es harren zur Zeit in Mittelamerika noch zahlreiche wichtige Fragen der Antwort und es ist daher mein lebhafter Wunsch, dass in naher Zukunft die geologische Erforschung dieses Gebiets energisch gefördert werden möge, damit einige der bedeutsamsten Rätsel der Entwicklungsgeschichte der Erdoberfläche gelöst werden können.

AUSZUG.

An dem Aufbau Mittelamerikas beteiligen sich archäische, paläozoische (Carbon), mesozoische (Trias und Kreide) und känozoische Formationen. Die nördlichsten Gebiete, Yucatan und Tabasco, bestehen aus fast horizontalen pliocänen und quartären Absätzen; die älteren Formationen sind beschränkt auf die beiden bogenförmig von W. nach E. durch Mittelamerika hindurchsetzenden Gebirgssysteme, das guatemaltekische im Norden und das costaricanische im Süden. Das nördliche Gebirgssystem zeigt Anzeichen einer nacharchäischen und einer nachcarbonischen Bildungsepoche; die heutige Grundgestalt erhielt es aber ebenso wie das südliche Gebirgssystem nach dem Miocän. Ein jugendliches Querstück, bestehend aus jungeruptiven Decken und Riffen (Mittelnicaragua) verbindet das nördliche und südliche Gebirgssystem.

Bei beiden Systemen befinden sich die *orogenetischen Centren*, die Herde der gebirgsbildenden Bewegung, nördlich von den Gebirgsketten, wie man aus der südwärts gerichteten Convexität der Gebirgsbogen erkennt. Weder das guatemaltekische, noch das costaricanische Gebirgssystem stellen einseitliche Bogen dar, vielmehr guirlan-

denförmig geteilte oder abgesetzte Curven, entstanden durch das Vorhandensein von jetzt nicht mehr nachweisbaren Widerlagern oder durch gleichzeitige Schubbewegungen von mehreren einander benachbarten orogenetischen Centren aus.

Fast senkrecht zum vorherrschenden "mittelamerikanischen Streichen" steht das "andine" Streichen, das O. Hershey auf der Halbinsel Azuero, Br. Mierisch in Ostnicaragua beobachtet hat. Unabhängig von beiden Streichrichtungen ist die Richtung der Vulcanreihen, die im nördlichen Mittelamerika in WNW.-ESE. gerichteten Linien südlich von ausgedehnten jungeruptiven Gebirgen hinzieht, in Costarica aber auf dem Kamm des nordcostaricanischen Bogens verläuft. Im ersteren Fall handelt es sich um disjunktive Dislokationen, im lezteren Fall verhinderte das Vorhandensein einer südlich vorgelagerten Gebirgsmasse eine Verschiebung der Eruptionslinie.

PHYSIOGRAPHY AND MAP DRAWING

By CARLOS DE MELLO

The ideas which I am now presenting have already been partially outlined and discussed in the Topographical Congress held at Paris in 1900 by the Société de Topographie de France,[a] which I have now the honor of representing in this congress.

The lack of generalization of the statical laws which I published in my book Les lois de la géographie rendered my propositions so difficult of comprehension that the Topographical Congress decided to reserve the solution of the questions involved for more competent authorities. The reason for the action was a double one: First, the obscurity of the statements or principles referred to; second, the lack of connection between topography, physical geography, and geology, the latter two not being at all considered by most topographers.

This is the time to protest against such limitation of topography, generally considered but a pure branch of mathematics, without any relation to physical geography and geology. It has been held that topography is only an application of trigonometry to measurements and representations of the forms of the surface of the earth, seeming thus to be independent of the perfect definition and of the exact knowledge of terrestrial morphology, the basis of geography and of geology.

With the exceptions of the topographies of Gannett (1893), Herbert Wilson (1900), and two or three more, the modern treatises attach no or little importance to the exact understanding of terrestrial morphology, which is considered only a decorative part of the drawing, having no connection with the history of the earth, notwithstanding the importance long ago given to it by the French Dépôt de la Guerre in its celebrated Mémorial topographique et militaire.

The fifth number of the Mémorial, in which General Vallongue endeavored to fix the topographical language, became so rare and so forgotten that Louis Puissant reprinted it in the second edition of his celebrated Traité de topographie.[b] He had thus the honor of generalizing and giving practical form to the ideas presented by Berchtold,[c]

[a] Bull. Soc. de Topographie de France, vol. 24, p. 125, Paris, 1900.

[b] Puissant, L., Traité de topographie, d'arpentage et de nivellement, p. 300, Paris, 1820.

[c] Berchtold, Comte, An essay to direct and extend the inquiries of patriotic travelers, 2 vols. 8°. London, 1789.

Dolomieu,[a] Romme,[b] Saussure,[c] Lehmann,[d] Andreossy,[e] and Brard,[f] who gave importance to the observation and representation of the external forms of the earth as a good way of understanding the agencies which had created them.

His suggestions, however, did not aid in the development of this scientific aspect of topography because of the high mental cultivation it required in topographers; and thus the observations which might be the basis of actual physiography or preliminary field geology were reduced to some notes in the mémoire or field note book of the topographer, and were limited to the greater accidents of the land without connection with their direction, importance, succession, and permanence.

The topographical charts suffered from such a bad tendency, and the scientific point of view, so strongly recommended by Puissant and his followers Dupuis Torcy and Brisson,[g] Lehmann,[h] Heusinger,[i] Hoffmann,[j] Ami Boué,[k] Herschell,[l] Richthofen,[m] Neumayer,[n] Kaltbrunner,[o] William Morris Davis,[p] Unschuld von Melasfeld,[q] T. C. Chamberlin,[r] Lapparent,[s] H. M. Wilson,[t] Chamberlain,[u] and others--was superseded

[a] Dolomieu, Deodat de, Notes communiquées à messieurs les naturalistes, qui font le voyage de la Mer du sud et des contrées voisines du pole austral, p. 310, Vol. II, Jour. Phys., Paris, 1791.

[b] Romme, G., Invitation aux voyageurs (pour apprécier ses vues géologiques), p. 59, No. V., an III, Journ. des Mines, Paris, 1795.

[c] Saussure, Horace de, Agenda, ou Tableau général des observations et des recherches dont des résultats doivent servir de base à la théorie de la terre, p. 1, No. 20, an IV, Journ. des Mines, Paris, 1796; afterwards reprinted and annexed to Vol. IV of Voyages dans les Alpes, 1796.

[d] Lehmann, Darstellung einer Theorie der Bergzeichnung der schefen Flächen im Grundriss, oder der Situationszeichnung der Berge, Leipzig, 1799.

[e] Andreossy, Ant. Fr., comte, Historie du canal du midi ou de Languedoc, 1 vol. 8°. Paris, 1800.

[f] Brard, C. P., Manuel du minéralogiste et du géologue voyageur, 1 vol. 12°. Paris, 1805.

[g] Dupuis Torcy et Brisson, B., Mémoire sur la configuration des points de partage des canaux (extrait sous le titre "Essais sur l'art de projeter les canaux de navigation"), Journ. de l'École Polytechnique p. 262, tome VII, cah. XIV, Paris, 1808.

[h] Lehmann, Joh. George, Anweisung zum richtigen Erkennen und genauen Abbilden der Erdoberflache, Dresden, 1812-1816.

[i] Heusinger, Johann H. G., Die Elementar-Geographie, oder die Topographie des Erdbodens als Grundlage jeder besonderer Geographie dargestellt. Leipzig, 1826.

[j] Hoffmann Carl, Allgemeine Einleitung in die physikalische Geographie and Grundzüge der Terrain Lehre. Breslau, 1831.

[k] Boué, Ami, Guide du géologue-voyageur, 2 vols. 12°. Paris, 1836.

[l] Herschell, Sir John F. W., Manual of scientific enquiry, 1 vol. London, 1849. 4th ed., revised by Robert Main. London, 1871.

[m] Richthofen, Ferd. von, Anleitung zu geologischen Beobachtungen auf Reisen (extract from Neumayer's "Anleitung"), Berlin, 1875. Führer, Forschungsreisende, 1 vol. Berlin, 1886; reprinted. Hannover, 1901.

[n] Neumayer, Georg, Anleitung zu wissenschaftlichen Beobachtungen auf Reisen. Berlin, 1875.

[o] Kaltbrunner, D., Manuel du voyageur. 1 vol. 8°. Zurich, 1879.

[p] Davis, William Morris, Geographic classification illustrated by a study of plains, plateaus, and their derivations, Proc. American Assoc., 1884. Geographic methods in geologic investigation, National Geographic Magazine, Vol. I, No. 1, Washington, 1888.

[q] Unschuld von Melasfeld, Terrainlehre eine gesonderte Wissenschaft. Als Vorschule für Geologie. 1 vol. 8°. Wien, 1884.

[r] Chamberlin, T. C., A proposed system of chronologic cartography on a physiographic basis, Bull. Geol. Soc. of America, 1891.

[s] Lapparent, Alb. de, L'art de lire les cartes géographiques, Rev. Scient., Vol. V, p. 385, Paris, 1896.

[t] Wilson, Herbert M., Topographic surveying. New York, 1900.

[u] Chamberlain, James F., Field and laboratory exercises in physical geography. New York, Cincinnati, etc., 1903.

by the personal impressions of the topographer and by the artistic fancy of the draftsman.

It is strange that Puissant should have been the man who exalted this artistic fancy by recommending the effects of shade for giving expression to the relief.[a] The draftsmen preferred then, if not always at least generally, the lateral light to the vertical or zenithal one, that being more favorable to the artistic effects of shade.

Thus the simplicity and the exactness of the representation of terrestrial forms were lost, and many features that were misleading to the student and false to nature were in this way generalized, tainting the maps with useless and deceptive decorations. Thus streams and large rivers running from north to south, or inversely, had always the western side strongly marked, as if the bank on that side were always higher than the other. In the same way streams and rivers running east to west, or inversely, had always the northern bank strongly marked, as if that side were the higher.

The same observations may be made on the drawings of lakes, moors, and swamps, in which the western and the northern margins were and are always marked with stronger lines than the opposite shores, in evident contrast with the natural truth.

In the representation of mountains the same abuse of the effects of shade was seen and is yet to be seen in some topographical maps that are perfect from other points of view. Mountain chains trending north to south have always the eastern slope steeper than the western because of the shade; chains extending east to west are always represented as if they had the southern slope steeper than the opposite. Isolated mountains presented for the same reason the eastern and the southern declivities steeper than the others.

The connection long ago established, but seemingly forgotten, between the forms of the earth's surface and their causes is now so well founded and demonstrated that we can no longer admit such fancies of design in this age of micrometrical observations with perfect instruments. In many modern topographical maps this connection receives scant recognition, especially in those which were planned and traced independently of or before those of the geological surveys; in others the hydrography is not exact; and there is little harmony in the topographical, geological, hydrographical, and nautical maps in the representation of the same forms or of similar forms of the earth's surface. This is to be seen especially in the drawing of the seacoasts, lake shores, and of the river banks.

The streams are yet represented in black ink in some maps and in blue ink in others; in some of them, topographical and geological, no importance is given to the elevation or domination of the river banks,

[a] Puissant, Louis, Traité de topographie, p. 235.

which is also forgotten in many modern books on topography, physiography, and physical geography.

We see by comparison of maps of the same region that there is no uniformity of representation, because the dominant bank of the same river is the left in some maps and the right in others. Yet it is easy to discover faults or omissions in the most perfect maps, as in the magnificent Karte des Deutschen Reiches on the scale of 1:100,000, where the Isar is faultily represented west of Ackdorf, the Danube east of Herrnsaal, of Bruckdorf, and of Strasskirchen, and south of Obernzell.

These facts can not be hidden from such a congress as this, many observations being dependent on good topographical or geological maps, especially on the exact drawing of the drainage waters and of the isohypses, or contour lines showing equal elevation.

I beg to insist on the exact drawing of the river bank's domination not only because of its obscurity in or omission from many modern maps, but because of its need and importance. It indicates:

1. The approximate position of the thalweg or channel, always nearer to the higher bank.

2. The vicinity, in structural valleys, of the highest mountain.

3. The direction, in architectural valleys, to which the rivers tend to migrate.

4. The stage of the stream's evolution.

5. The side on which the river deposits its material—opposite to that of the stronger corrasion.

6. The existence of a general force when many neighboring rivers have the dominant bank at the same side, or when many distant rivers running in parallel directions have the dominant bank at the same side.

If we consider the lakes, we find that, outside of the admirable works of Forel, Delebecque, Gilbert, Albrecht Penck, Sir John Murray, Pullar, and a few others, no special attention is given to them in topographical and geological maps. First, no importance or small importance is given to their bathymetry, as if they could exist without depths; second, their shores are indifferently considered, because they are either drawn with lines of equal thickness, as if they were always equal in height, or represented with effects of lateral light, the western and the northern shores being always more marked than the opposite. This strange fancy is not one of private or common official topographic mapmakers. It is to be seen in many good maps, and also in the Karte des Deutschen Reiches (which I cite because it is one of the most celebrated), where the margins of many lakes are badly represented on some sheets, as the Rim and the Sims in sheet 652; the Chiem, Tachinger, and Waginger in 653; the Trumer, Seekirchner, Irr, and Abdorf in 654; the Deger in 660; the Niedersonthfur in 661;

the Hopfen, Weisen, and Bannwold in 662; the Staffel, Rieg, Koch, and Walchen in 663.

In view of the completeness and exactness which science is every day more and more desiring and demanding, the importance of such a perfect representation of lakes, with the isohypses of their environment, can not be overestimated. Their bathymetry is absolutely needful for representing the real shape of their basins—the exact conformation of their bottoms.

The general direction of neighboring lakes, especially when their deepest basins have the same orientation and disposition, and the equal or similar disposition of their shores, depths, and basins may throw some light on their common origin, especially when they are excavated in rocks of equal texture and age, or when they are produced by the same cause, either glacial or volcanic, etc.

To conclude, then, since these faults are in themselves sufficient justification for these lines, I beg in this session to recommend to the congress the adoption of the following principles:

I. That topographers ought to be instructed in geology, or at least in physiography.[a]

II. That in map drawing much more attention should be given to the complete and exact representation of lakes and surface-drainage waters.

III. That in map drawing by hachures the vertical light shall always be adopted.

IV. That it is always preferable to use isohypses, or contour lines, instead of hachures.

V. That the isohypses should be kept in geological maps.

VI. That lakes and drainage waters should always be printed in blue ink.

VII. That complete uniformity should be established as to the signs employed on topographical, hydrographical, and nautical maps.

VIII. That geographical maps, so far as their scales will permit, should conform with topographical charts in the forms of their conventional signs.

IX. That the decimal system should be finally adopted and practically realized.

[a] Wilson, op. cit., p. 1. La Noë et de Margerie, Les formes du terrain, Paris, 1888. Sopwith, T., A treatise on isometrical drawing, London, 1834.

PHYSICAL HISTORY OF THE WINDWARD ISLANDS AS ILLUSTRATED IN THE LARGER STORY OF PELÉE—A STUDY OF VOLCANIC AND OCEANIC GEOGRAPHY

By ROBERT T. HILL, New York City

[Abstract.]

In this paper the author shows that the recent West Indian eruptions, from a geographical point of view, instead of being sudden, catastrophal, and destructive, are progressive constructional phenomena of the interior world mechanism, which have been in operation in this vicinity at least as far back as in Cretaceous time, and that the aggregate product of their work has been the construction of habitable lands, as islands, above the ocean's floor by the processes of volcanic pile-up.

It is also shown that the masses of the present islands composed of erupted volcanic material convey but a faint idea of the totality of work which has been performed by these vents in transferring material from the earth's interior to its outer envelope. The greater part of this material is distributed into the atmosphere and surrounding oceans, rather than at the immediate vicinity, while that which is being preserved as added height to the island masses is the algebraic remainder of a vastly greater quantity of material which is being worn away and has constantly been worn away by destructive action of atmospheric and marine erosion.

The great epeirogenic movements of the earth's crust in this vicinity (regional uplifts of the earth's crust without deformation) are also pointed out, although their relation to the volcanic extrusions is not explained.

In conclusion, as a result of minute geologic, paleontologic, and physiographic studies, it is shown that the recent eruptions can not be connected with seismic fissures letting in the waters of the ocean, or other crustal causes, and a summary is presented of the accumulating evidence and recent conclusions within the last few years of Arrhenius, Geikie, Suess, Gautier, and others, whereby it seems more probable

that the oceans do not make the volcanoes, but on the contrary volcanoes are the mechanisms through which the world at work is constantly transferring material from its hereditary gaseous center, thereby thickening its rock crust and adding water and gases to its aqueous and atmospheric envelopes.

CONTENTS

METEOROLOGICAL SUMMARY FOR AGAÑA, ISLAND OF GUAM, FOR 1902

By CLEVELAND ABBE, Jr., U. S. Geological Survey

I. GEOGRAPHICAL POSITION

The island of Guam is the southernmost of the Marianas group, and lies approximately in latitude 13° 36′ north and longitude 144° 45′ east. Agaña, on Guam, is the chief settlement and seat of government for the whole group and is situated at about the middle of the northwest coast of the island.[a]

The island seems to be in large part of volcanic origin, since the more elevated land is reported to consist of volcanic rock, and reports say that a peculiar white mud-like earth charged with hydrocarbon gases oozes from many crevices in the hilly districts.[b] The southern portion of the island has hills attaining heights approximating 1,000 feet, but to the northeast these hills descend rapidly to a level-topped plateau of coralline limestone, which has a remarkably uniform elevation of about 300 feet.[c] In one place northeast of Agaña a small group of volcanic peaks reaches up from beneath the limestone plateau to a moderate elevation above it.

The other islands of the Marianas group are essentially reef-fringed volcanic islands and are probably located over the continuation of the same set of fissures that determines the position of the Volcan, Bouin, and Ooshima groups of volcanic islands and the Amagisan-Fujisan line of volcanic peaks on Nippon. Most of the islands and peaks of this long subaerial and submarine ridge are active volcanoes. Probably the seismic disturbances, which on Guam attain greater importance than the volcanic phenomena, are connected with the location of the island on this great fissure zone.

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[a] Latitude and longitude taken from the Philippine Weather Bureau Bulletin, Sept., 1902, p. 207.
[b] Op. cit., p. 206.
[c] See Report of Guam Survey Board to the Secretary of the Navy, Washington, D. C., 1902, chart 5.

II. SOURCES OF METEOROLOGICAL DATA

LENGTH OF RECORD

The data used in this brief report consist chiefly of observations carried on by members of the naval force stationed at the United States naval station at Agaña. The records have been kept since the 1st of November, 1901, and have been very kindly loaned by the authorities of the United States Hydrographic Office for use in compiling this report. Special acknowledgment is also due to the Hydrographic Office and United States Naval Observatory for information courteously given regarding the records and the instruments used.

ELEMENTS OBSERVED

The recorded data consist of hourly readings of the direction and velocity of the wind; barometer and attached thermometer; dry and wet bulb thermometers; form, direction of movement, and amount of clouds; the general weather conditions, and daily records of rainfall.

In addition, careful observations on earthquakes have been recorded, but no seismographic records seems to be available if any are in existence, which is doubtful.

INSTRUMENTS USED

The instruments used in observing are those usually furnished to the United States naval stations and are of the patterns called for by the contract specifications at the time the station was established, viz, 1900-1901. They are as follows:

1 cistern-barometer, made by Green, New York (marine type).
1 dry-bulb thermometer, made by Green, New York.
1 wet-bulb thermometer, made by Green, New York (water cup and wick type).
1 Robinson anemometer.
1 wind vane.
Rain gauge.

The thermometers furnished to the naval stations are required to read to single degrees on the scale, and are accepted if they register temperature correctly to within one-half of a degree. In practice they are read to the nearest degree.

The barometer is read to the nearest one-hundredth inch and its attached thermometer to the nearest degree. In November, 1902, the station barometer at Agaña was compared with the ship's barometer of the United States transport and found to be too low by 0.08 inch.

The anemometer readings have always been recorded to the nearest two-tenth miles.

The character of the rain gauge has not been ascertained.

EXPOSURE OF INSTRUMENTS

This important element in the critical study and comparison of meteorological observations can be given here only according to verbal descriptions from memory by ex-Lieut. W. E. Safford and Commander Seaton Schroeder, as no published or manuscript description of the same is known to exist.

From the descriptions by these two gentlemen, formerly lieutenant-governor and governor, respectively, of the island, it would appear that the barometer and the wet-dry bulb combination hung within the main hallway of the governor's residence, sheltered from the direct solar rays by the usual portico or porch, but possibly not having a free current of air, since the end of the hallway is blocked by a staircase. The residence, in common with the larger part of the town of Agaña, stands on a broad terrace about 12 feet above sea level. It is on the northwest side of the island and below the top of the plateau already mentioned. It is quite likely that the water cup of the wet-bulb thermometer was not always properly supplied with water.

The wind vane and the anemometer are supposed to have been exposed at the ruined fort on the top of the bluff south of the town. From chart 2 of the report already referred to the elevation of this fort is 160 feet above mean tide. This location seems to be well exposed for most winds. It is, however, somewhat sheltered from southeast, south, and southwest winds by the high lands of the southern and eastern portions of the island.

As to the exposure of the rain gauge, no information has been received.

III. CLIMATOLOGICAL ELEMENTS HERE CONSIDERED

Out of a much larger number of the elements entering into the climate of tropical and subtropical localities the temperature, precipitation, and wind have been chosen for this brief report. These are, indeed, among the fundamental elements, and in this particular case they seem to be worthy of the most reliance.

These three elements have been summarized for 1902 and the results presented both graphically and in numerical tables.

IV. TEMPERATURE RECORD, 1902

TEMPERATURE AS A CLIMATIC FACTOR

The following list of the most important temperature data is given by Prof. Julius Hann:[a]

1. The mean monthly and mean annual temperatures of the air (see column 5 of Table I).

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[a] Hann: Handbook of Climatology. Translated by R. De C. Ward. Part 1. General Climatology. New York, 1903, pp. 28–29.

2. The extent of the mean diurnal range of temperature for each month (see column 8 of Table I).

3. The mean temperature at the different hours of observation for each month (see columns 2, 3, and 4 of Table I).

4. The extreme limits of the mean temperatures of the individual months * * * and the mean variability of the monthly means, if a long series of years is available.

5. The mean monthly and mean annual extreme temperatures and the resulting nonperiodic mean monthly and mean annual range and the mean maximum and mean minimum temperatures for the year.

6. The absolute maximum and minimum temperatures observed within a given interval of time (see columns 6 and 7 of Table I).

7. The mean variability of temperature, as expressed by the mean of the differences between consecutive daily means. * * *

8. The average limits or dates of frosts * * * and number of days free from frost, or the so-called season of growth.

Owing to the limited length of time covered by the observations, viz, January–December, 1902, several of these elements could not be calculated, but among those in the above list the following are to be found in Table I:

1. The mean monthly and mean annual temperatures of the air, in column 5.

2. The extent of the mean diurnal range of temperature for each month of 1902, in column 8.

3. The mean temperature at each hour of observation for each month and for the year 1902, in columns 2, 3, and 4.

6. The absolute maximum and minimum temperatures observed for each month and for the year 1902, as nearly as they can be determined from hourly observations of the dry bulb, without maximum and minimum thermometers, in columns 6 and 7.

Lying as the island does within the northern tropic and at a low elevation, the records of course show no occurrence of frost.

PREPARATION OF TABLE AND DIAGRAMS

The means and other values presented by the table were obtained as follows: From the hourly readings were selected the daily readings at 7 a. m., 2 p. m., and 9 p. m., and from these the mean temperature for each day was calculated by the formula:

$$M=\tfrac{1}{4}\,(7_a+2_p+9_p+9_p).$$

This formula gives a daily mean whose value varies very little from the mean obtained by the formula $\frac{1}{2}$ (max.+min.), and frequently agrees exactly. From the tri-daily readings and their means were obtained the four mean values given in columns 2, 3, 4, and 5 of Table I.

From among the 24 hourly readings of each day the highest and the lowest temperatures recorded were selected as the maximum and minimum for that day. From these was obtained the range for the day, and in column 8 are given the mean daily ranges for each month.

The absolute maximum and minimum for each month were selected from the daily maxima and minima and entered in columns 6 and 7,

respectively. The extreme limits of temperature for the year are found at the foot of these columns, while the mean maximum and mean minimum for the year, as obtained from a long series of annual maxima and minima, obviously could not be calculated. The mean values given at the foot of the columns are always means of the twelve monthly values.

The conversions into centigrade degrees, in the columns headed "°C." were made by aid of the "International Meteorological Tables."[a]

Certain features of temperature, rainfall, and wind have also been presented graphically. The temperature elements thus presented are:

(*a*) Mean monthly temperatures.

(*b*) Mean tri-daily temperatures for each month.

(*c*) Mean monthly maxima and minima for each month.

(*d*) Absolute maxima and minima for each month.

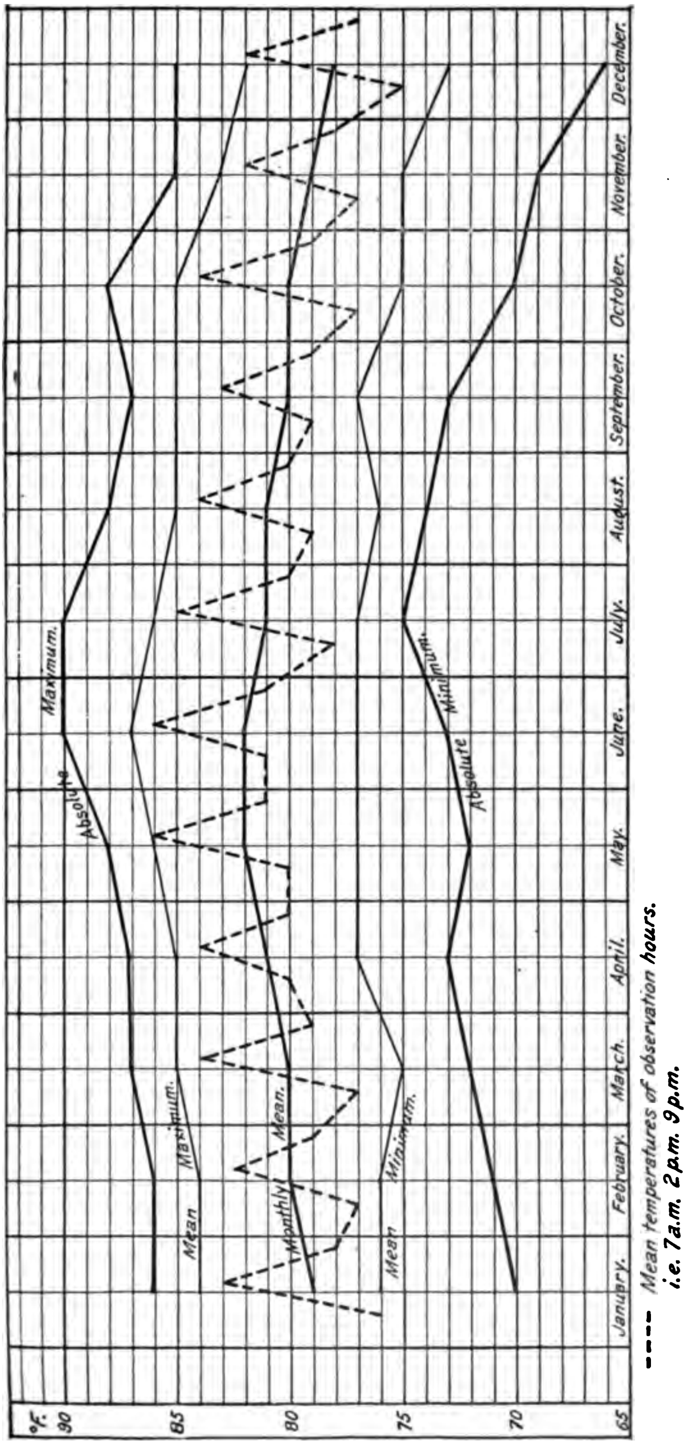
DISCUSSION OF TABLE AND DIAGRAM

Table I, column 5, shows the mean temperatures, monthly and annual, for the year 1902. The mean temperature of the year was about 80° F. (26.7° C.), and a simple inspection of the monthly means shows that the average temperature of any month did not vary more than 2° F. (1.1° C.) on either side of this mean. The greatest departures of individual temperatures from this mean, however, were much larger, as is shown by comparing the lists of absolute maxima and minima. The maximum departures among the monthly means amounted to +2° F. in May and June, and −2° F. in December, but the absolute maximum departures reached +10° F. in June and July, and −14° F. in December.

It is further interesting to note that the months of February, March, September, and October had the same mean temperature as that of the year.

The annual march of temperature (as it is expressed in column 5) is seen to consist of a very gradual rise from December to May, a constant, moderately high temperature through May and June, and then a somewhat more gradual descent through July, August, September, and October to the minimum, which was reached in December. While this is the general course of the mean temperatures through the year, column 6 shows that the absolute maximum was not reached until June, or one month later than the attainment of the maximum of the mean monthly temperatures, and that the absolute maximum temperature occurred in July, or during the first month of decrease in the mean monthly temperature. An inspection of the daily records for June and July shows, however, that the absolute maximum temperature occurred but once in July, viz. on the 11th instant, whereas it occurred three times and was also approached frequently during June.

[a] Tables météorologiques internationales, Paris, 1890.



Temperature curves for Agaña, Guam, for 1902.

On the other hand, the minimum mean monthly temperature was reached in the month of December and the absolute minimum temperature was also confined to this month, as is shown by comparing columns 5 and 7, although it was once closely approached in November. The minimum temperature was, however, reached but once and with what one might call great difficulty, since it is 7° F. lower than the mean daily minimum for its month, December, and was approached only within 3° F. on two other days of that month.

In general, the monthly means show that in 1902 the spring months, March to May, were slightly warmer than the autumn months, September to November. Spring had an average temperature of 79° F. The winter months, December to February, had also an average of 79° F.; and the summer months, June to August, show an average of 81° F., or only 2° F. higher than that of the spring months. The autumn average was 26.5° C. From these groupings it is evident that there was an almost inappreciable change of temperature from one seasonal group to another, so that it is scarcely proper to speak of the climate as showing four distinct seasons.

The temperature element may, however, be divided into two seasons by grouping the months about the maximum and minimum temperatures, which suggests something like a hot season from April to September and a cooler season from October to March. This seasonal division is more evident when the rain table is examined.

The average daily march in temperature, as shown by columns 2, 3, and 4, accords with the usual or normal type, viz, minima occurring in the early morning hours, maxima within three or four hours after midday. Although the monthly and annual averages for the hours 7 a. m., 2 p. m., and 9 p. m. point to this general rule, yet it should be remarked here that on several days in different months the daily maximum temperature occurred during morning hours and the minimum during noon or afternoon hours. On one day the maximum occurred at 1 or 2 a. m. and the minimum about 2 or 3 p. m., but such abnormal conditions seem to have been brought about by changes in wind direction during the respective days.

It is interesting to note that the annual march of temperature for the three selected hours follows almost the same path as that of the monthly means, but seems to run ahead of the latter at times. Thus the four temperatures reach their maxima in May and June, but the mean 7 a. m. temperature has its maximum in June only, and shows somewhat more rapid ascents and descents than the other three means. The curves also all reach their minima during November or December, but the means of 7 a. m., 9 p. m., and the month have their minima in December only, whereas the 2 p. m. mean reaches its minimum in November and stays close to that value through December. In other words, the 7 a. m. and 9 p. m. temperatures passed through greater

ranges, 6° F. and 4° F., respectively, during the year than did the 2 p. m. temperature (4°), but there was little difference in the ranges of 2 and 9 p. m. and monthly mean temperatures.

The daily range in temperature, shown in column 8, is seen to be rather variable, yet it shows a steady tendency to increase from about 8° F. in January and February to 10° and 11° in September, October, and November. The rate of change seems to have been very slow, but was interrupted by some very great jumps one way or the other. These jumps really result from the behavior during periods of several days within which still greater actual ranges occurred. For example, March showed an average daily range of 10° F., but during the days 1 to 3 and 14 to 17 the range was from 10° to 13° F., and on the 5th and 19th the range was 15° F. and 14° F., respectively.

The season of minimum range seems to have been January to April and that of maximum range June to December. It is not permissible, however, to draw any general conclusions from these figures, because they represent the conditions during a single year, and we have no other records for Guam.

In column 8 are given the amounts and dates of occurrence of the maximum and minimum ranges of the year, viz, maximum, 17° F. on June 23, 1902, and minimum, 3° F. on November 10, 1902.

RELATIVE POSITION OF GUAM AS TO TEMPERATURE

The geographical position of Guam brings it under tropica marine climatic conditions, since it is an island lying between the northern tropic and the equator. This brings the island within the "hot belt," or the zone having annual mean temperatures of 20° C. or higher; but it lies about 13° of latitude north of the heat equator, the axis of this hot belt.

According to Supan's Chart of Climatic Provinces,[a] Guam, in common with many other islands of the Pacific, lies beyond the boundaries of the climatic divisions explicitly named by him. Perhaps this indicates that these islands appeared to Supan to have normal marine climates.

Further comparisons[a] show that Guam lies in a region whose mean annual minimum, as charted, is 15° C., and maximum is 30° C., while the mean annual extreme range is 10° C. The extreme range observed at Guam during 1902 was 13.3° C., or 3.3° C. above the supposed normal for that general region. The absolute maximum for the year was 32.2° C., and the mean of the monthly maxima was 30.6° C. Thus the year's maximum was 2.2° C., and the mean monthly maximum was only 0.6° C. above the normals of Supan's charts.

The absolute minimum at Guam was 18.9° C., or 3.9° C. above the normal minimum of the maps, and the mean monthly minimum for

[a] J. G. Bartholomew: Physical Atlas. Vol. III. Meteorology. London, 1899. Plates I, II.

1902 was 22.2° C., or 7.2° C. above the assumed normal. The mean temperature of the year was 26.7° C., while the charts of Bartholomew's Atlas[a] give an annual mean temperature of about 25.28° C., or a little higher, since Guam lies between this annual isotherm and the thermal equator.

These comparisons indicate that the year 1902 was, as a whole, slightly warmer than normal, and that the year's range in temperature, while of greater amplitude than was perhaps to be expected, was due to the excess of the year's maximum temperatures and not to the low minima.

Concerning the class to which the climate of Guam belongs, the tables and the diagram of temperatures give the following points:

(*a*) The spring months were a little warmer at Guam than the autumn months in 1902, while in a typical marine climate spring may be expected to be cold and autumn warm.

(*b*) The retard of temperature maxima and minima, with reference to the least and greatest declination of the sun, is at Guam about one month for the maximum temperature of June and July, and also one month for the minimum temperature of December.

In a typical marine climate the maximum temperatures would be expected to occur in August and the minimum temperatures in February or March; although in these points Guam, during 1902, diverged from the typical year in a marine climate, nevertheless, it adhered to one general rule, i. e., that the mean temperature rose from December to May and fell from June to December. The rise in temperature was typically[b] more rapid than the fall. The same was also true in general for the mean monthly maximum temperatures, as may be seen by examining the accompanying temperature curves for the year.

V. RAINFALL IN 1902

ATMOSPHERIC MOISTURE AS A CLIMATIC FACTOR

The fall of rain and snow is a climatic factor whose importance is widely recognized, and it is the object of general and particular observation. Some of the most interesting and valuable characteristics of the rainfall, in addition to the monthly and annual totals, are the number of days on which a measurable amount of rain fell, the number of days on which given larger amounts of rain fell, and the relation between the total amount of rain and the total number of days required to precipitate it. In certain localities and climates it becomes important to know the maximum rainfall per hour. Sometimes even the amount of dew forming during the nights is a very important climatic factor. Another element of general interest is the "probability of rain," obtained by dividing the average number of rainy days in a month,

[a] Bartholomew, J. G., Physical Atlas. Vol. III. Meteorology. London, 1899. Plates I, II.
[b] Hann: Handbook of Climatology. Translated by R. DeC. Ward. New York, 1903, pp. 140-141.

or other period, by the total number of days in that period. Such a table, as well as one giving the maximum hourly rainfalls each month, would be of great value for such a climate as that of Guam, but the data are not at hand, as we have hourly measurements of rainfall for only four months.

The relative humidity is a climatic element of the greatest importance, especially in such climates as the one under discussion, because of its close relation to the rate of evaporation from plants and animals, but it appears best not to attempt a discussion of this factor, since the readings of wet-bulb and dry-bulb thermometers were not made with the standard sling psychrometer. The copious rainfall of every month of the year is good evidence of the large amount of moisture present in the air of the island.

For consideration in the present report the following features of the annual rainfall have been selected:

(*a*) Total monthly and annual rainfall.
(*b*) Maximum monthly and annual rainfall in twenty-four hours.
(*c*) The total number of days with rain and the number of days with more than 0.1, 0.5, and 1 inch, respectively.
(*d*) The rain intensity for each month and the year.

PREPARATION OF TABLES AND DIAGRAMS

The accompanying table (Table I), showing various features of the rainfall at Agaña during 1902, is based on the series of daily observations made at the United States naval station at that place. No information is obtainable bearing on pattern or exposure of the rain gauge; therefore the records must be taken just as they stand. Up to the end of February hourly readings of the rain gauge were recorded, but beginning with March 1 only the total rainfall for twenty-four hours ending with noon of the date to which it is ascribed found a place in the reports.

From these daily totals were obtained the totals for each month, as given in the first column of Table II, and the original readings in English inches were then converted to millimeters. The total rainfall for the year and the monthly totals enable us to calculate the monthly percentages of the annual rainfall, or the annual distribution of rainfall, as given in column 2, headed "Percentages of annual rainfall."

The maximum daily rainfall occurring during each month was selected from the daily rainfalls, and is given in column 3.

In column 4 is given the number of days on which more than a "trace" of rain fell during the month. The following three columns show in a similar way the number of days on which more than 0.1, 0.5, and 1 inch of rain fell.

In the last column (8) is given for each month the relation between the total rainfall of the month and the number of days on which rain fell during that month. These figures were obtained by dividing the

rainfalls in column 1 by the number of days of rain in column 4, and they thus show the average intensity of the rainfall for a rainy day in each month of the year 1902. This datum in particular varies very much from year to year, and the monthly figures would probably be very different if the length of the record were greater.

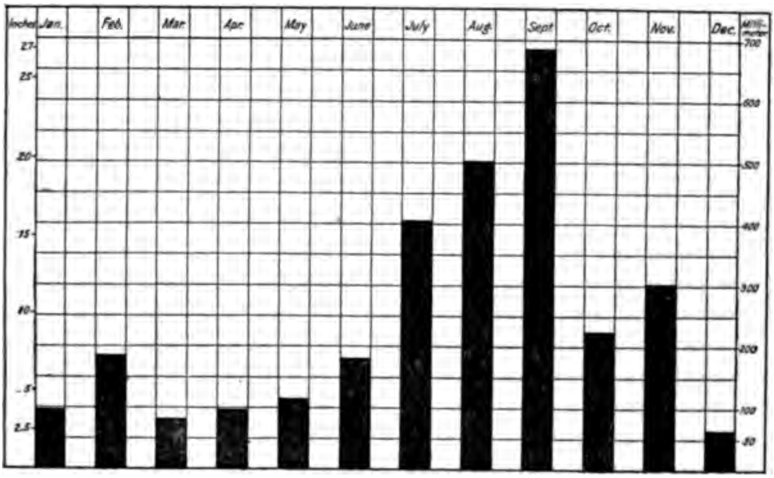
DISCUSSION OF TABLE AND DIAGRAMS

In looking over the first three columns of the table of rainfall for 1902 at Agaña the first fact to be noticed is the generally abundant rain recorded throughout the year. Column 2 shows immediately that no month had less than 2 per cent of the total for the year; that nearly all had more than 3 per cent, and that four months had not less than 10 per cent each. The generally rainy character of the climate is shown in column 4, where it appears that rain fell on not less than fifteen days in every month. Although these figures show that much rain falls and that there is a large proportion of rainy days in the year, still the humidity of the climate would be most truly shown by averages of the relative atmospheric humidity for the months, or by the average amounts of soil moisture for the months, data which must still be obtained before the features of the climate that are biologically most important can be accurately known or discussed.

As regards the distribution of rain from month to month throughout the year, the first column shows a very distinct division of the year into two seasons. During the months from December to June there was a distinct minimum of rainfall, and from June to December there was a distinct maximum. If this annual march of the rainfall be compared with the annual march of the temperature (which is most conveniently done by superposing the respective diagrams), it will appear that while the maximum temperatures did occur during the rainy season they came earlier than the heaviest rains. It is probably a coincidence that in 1902 the minimum rainfall occurs in the same month as the minimum temperatures; nevertheless December is known to the islanders as the month in which the roads on the island begin to be passable because of the decreasing frequency of rain. As might be expected, the maximum rainfall in twenty-four hours, the number of days of rain per month, and the intensity of the rainfall, all rise as the rainy season advances, reaching their maxima usually in July or August. All three of these elements decrease very rapidly from November to January, while they increase very gradually from February to June, and then rise rapidly again to their maxima in August and September.

When the details of the table and diagram are more closely studied, various other regularities and irregularities appear. Thus, the monthly totals do not show a uniform or smooth transition from one month to the next. Particularly strong are the contrasts which

February and November present. The graphic table of the rainfall shows that some very heavy daily rains, which were caused by special storms, occurred in both these months in 1902. Thus, February 13 had a rainfall of 2.24 inches, which was nearly one-third of the total for that month. A comparison of the Philippine rainfall for February, 1902, shows that the latter islands also had an excessive rainfall in the month, which was provisionally explained[a] as resulting from an unusually marked and persistent period of high pressure embracing eastern Asia and the Philippines. The total precipitation in November was largely affected by the amount which fell on the 10th of the month. It appears from the meteorological Report of the Philippine Weather Bureau[b] that the monthly rainfall in that region was 50 per cent lower than the thirty-seven-year mean and that the



Monthly rainfall at Agaña, Guam, in 1902.

peace of the month was disturbed by a typhoon from the 6th to the 12th. Consequent upon this typhoon, a low-pressure area gradually embraced the archipelago. The records of pressure and wind at Guam show that on the night of the 9th–10th this low area was already forming over the northern part of the Marianas and that it was inducing a south wind and heavy rains in Guam.

An inspection of columns 4, 5, 6, and 7 of Table II shows some interesting facts concerning the relations between the total number of rainy days and the number of days with various amounts of rain. Thus it appears that on about one-half of the rainy days of any month more than one-tenth inch of rain fell, while, except in August and September, the proportion of rainy days on which more than one-half

[a] Philippine Weather Bureau Bulletin for February, 1902, pp. 18, 19.
[b] Philippine Weather Bureau Bulletin for November, 1902, pp. 271-272

an inch falls rarely exceeds one-third. In August and September, months during which nearly every day of rain has at least one-tenth of an inch, about one-half of those days have more than one-half inch, and one-seventh and one-fourth, respectively, have more than 1 inch of rain each. On the other hand, no day in December, March, April, or May had as much as 1 inch of rain, and January and June had only one day apiece on which an inch fell.

A general comparison of Tables II and IV shows that the months of maximum rainfall in 1902 were characterized by variable south, southeast, and southwest winds of generally low velocities. The less rainy months, November, December, January, and others had prevailingly east and northeast winds of decidedly higher velocities. The month which, in general, had the heaviest rainfalls was September, and it appears that during this month the wind was prevailingly southwest and had the maximum mean velocity, while the gusts, which once or twice slightly injured the anemometer, attained a velocity of 54 miles per hour.

The lower altitudes of the west and northwest coasts of the island and the higher land near the east coast combine to produce somewhat heavier rains in Agaña during prevailing west or northwest winds, but the year's record suggests that this distribution of topographic features hardly exerts an important influence upon Agaña's rainfall. As the rainfall record here given applies to Agaña alone, and may possibly be based on data from a poorly exposed gauge, no general conclusions as to the distribution of rain over the island throughout the year should be drawn from it.

The accompanying Table III, compiled from Herbertson's Monthly Rain Charts for the World, as given in Bartholomew's Atlas, plate 20, and from Table II, shows something of the relation between the Philippine, New Guinea, and Agaña rainfalls.

VI. WINDS AND STORMS

WIND AS A CLIMATIC FACTOR

In the Torrid Zone in general, and particularly among the more eastern islands of the western Pacific, it is probable that the wind does not play a very important part in determining the climate. If the islands happen to lie within the areas affected by the various Asiatic and Australian monsoons the winds are then more important.

In general, the winds at any place control the seasonal temperatures and humidities, but at Guam every wind brings large quantities of moisture, and in this respect the different winds do not show great variations such as they do, for example, in India. On the other hand, the general tendency of all winds to equalize temperatures is best seen on islands, particularly on small ones, since they all tend to bring down the summer temperatures of the small land mass to the temperate

ocean warmth, and to raise the winter or cool season temperatures to the still milder temperatures prevailing over the ocean.

Where an island is small enough and low enough to be completely swept by all the stronger winds belonging properly to the ocean, it is to be expected that the temperatures and humidities of the island will closely depend upon those of the air over the neighboring water. But during seasons of very weak oceanic winds the other climatic elements come more strongly under the influence of the land area.

The general effects of various wind velocities and directions upon animal organisms[a] are felt as stimulating and invigorating when a brisk air movement constantly brings fresh air and prevents stagnant air collecting in valleys. But enervation, inactivity, and poorer health accompany low wind velocities and calms in tropical regions and even in extra-tropical regions. In active volcanic districts wind velocities and prevailing seasonal wind directions play an important part in determining the distribution of fauna, flora, and human settlements. Fortunately in Guam the known volcanoes of the Santa Rosa group are probably extinct; otherwise the prevailing northeast winds would make nearly the whole island unsafe for habitation and agriculture.

From these brief considerations it is evident that the direction and the velocity of the wind for the months and the seasons and even for hours of the day are important features in any climate, and must be considered in our study of Guam.

PREPARATION OF TABLE IV AND DIAGRAMS

As was noted in a previous paragraph, the meteorological record for Agaña includes hourly readings of the anemometer dial and of the wind direction generally, with determinations of the actual momentary wind velocity every fourth hour.

In compiling Table IV the prevailing wind directions for each day of the month were obtained by inspection from the record of hourly observations, and the number of days in the month during which each direction prevailed were then brought together in columns 1 to 9.

From the readings of the anemometer dials at each midnight were obtained the total number of miles traveled in twenty-four hours, and by simply taking note of how many complete thousands were covered the number of miles per month was obtained from the first and the last readings in the month. The total distance for the month divided by the number of days gave the average daily distances entered in column 10, and these divided by twenty-four hours gave the average hourly velocities in each month, as found in column 11.

A graphic presentation of the facts given in columns 1 to 9 is found on the accompanying cut showing monthly wind-roses (page 261), where the relative frequency of the prevalence of each wind has been

[a] See Hann-Ward, op. cit., pp. 67 et seq.

expressed in percentages of the total number of windy days. Each wind direction occurring during any given month is indicated by a line drawn from O in the respective directions; according to the usual arrangement N is toward the top of the figure and E toward the right, perpendicular to N. The relative frequency of each wind is indicated by the length of its line. Under each diagram is given the name of the month whose wind it represents and the percentage of days with variable winds during that month; the latter important factor could not well be presented graphically on the diagram.

For example, the diagram for April shows that 67 per cent of its winds were from the northeast, 28 per cent from the east, and 5 per cent from the southeast, while the absence of lines in other directions, and the statement Var. = 0 per cent, shows that these were the only winds blowing during the month.

DISCUSSION OF WINDS

By a study of the table of wind directions, Table IV, columns 1 to 9, it appears that considering the year as a whole the rarest winds were from the north, northwest, and west, and next to these the southwest, south, and southeast. The predominant winds were the east and northeast.

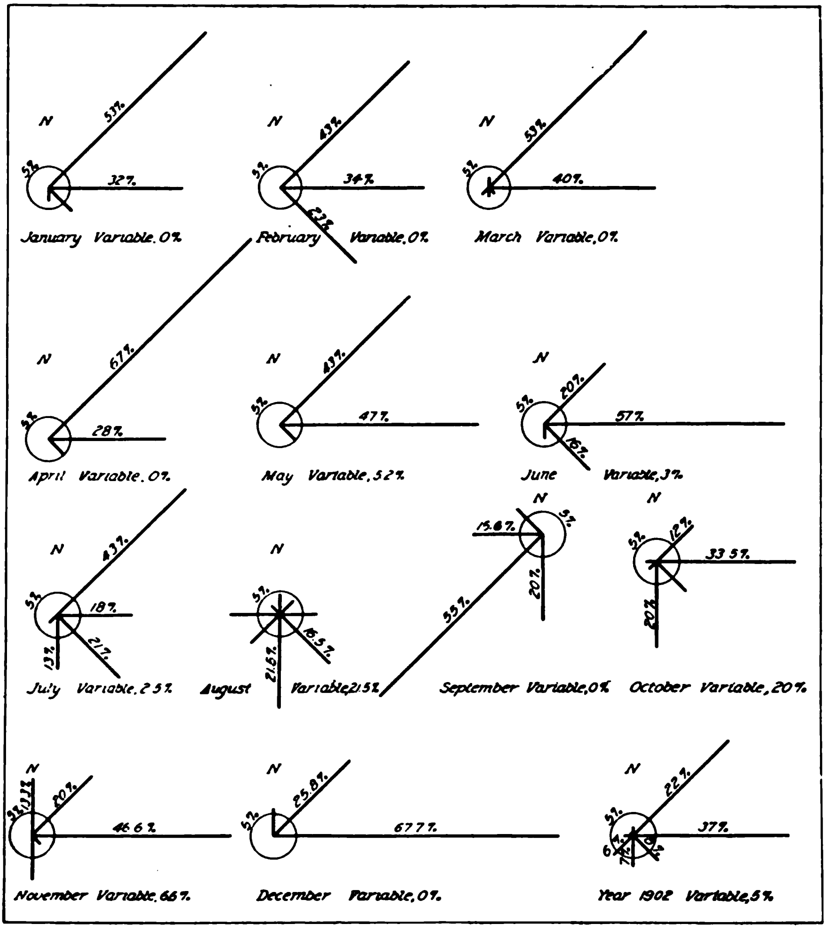
With reference to the prevailing direction during different months, the table shows that the strongly prevailing east wind of December changed to more frequent northeast winds during the period January to April, but during May this northeast wind tended to return to east, a tendency which by June seemed to have become fixed. In July the wind veered from the northeast frequently toward east and southeast, and so also during the weak, variable winds of August, yet the predominant winds lay between south and southeast. In August there were eleven and one-half days of south or southeast winds, six and one-half days of variable winds, and at most only three and one-half days from any other direction.

The general southerly tendency of the winds made its first appearance in July and by September the southwest wind became predominant, lasting through that month. The average velocity of this southwest wind of September was greater than that of any other wind during 1902 and it seems to be what Admiral Krusenstern, Lieutenant Carmago, Gen. Jos. Wheeler, and others have called the southwest monsoon. The following quotation[a] from notes by Lieut. W. E. Safford, accompanying General Wheeler's Report on the Island of Guam, gives the correct names of the different winds and describes accurately the general characteristics of the weather accompanying each:

"The temperature is mild and much cooler than that of the Philippines, but the inhabitants declared that the heat in August and Sep-

[a] War Dept., Adj. Gen. Off., No. XXVIII. Report on the Island of Guam, 1900, pp. 21, passim.

tember was almost suffocating. This must arise from the interruption of the northeast trade wind, which blows throughout the year, with the exception of these two months, during which the effects of the southwest monsoon apparently reach to the Marianas. At this time there is generally a dead calm, for the monsoon itself has not sufficient force to reach an archipelago. It is, therefore, the season of intense heat, rain, and storms, and frequently of terrible hurricanes."



Monthly wind roses for Agaña, Guam, for 1902.

A quotation from Lieutenant Carmago, writing in 1873, given on page 23 of General Wheeler's report, says: "During July and August it [the monsoon] blows from the southwest; it has less strength [than the northeast monsoon], but is accompanied by strong squalls and heavy rains." Concerning the strength of the winds of August, column 10 of our table shows that they are weaker than at any other time. The daily records show, however, that then the southwest wind was

frequently accompanied by "gusty winds all day," whose velocities ran up to 36 and even 54 miles per hour during periods of one or two minutes. In October, 1902, two gusty days also occurred with equally violent winds, but the winds were from the southeast and northeast and probably were due to the passing of a typhoon to the south of the island.

Columns 10 and 11 of Table IV, taken alone, show a slight gradual increase in the hourly velocities from January to April, but a rather sudden jump from low and almost calm conditions in August to the violent September winds, and then a drop to the gentle reawakening of the northeast trade during October. Through November and December and from February to June these northeast trades appear to have blown rather steadily at a rate of between 9 and 10 miles per hour, while during July, August, and October the wind velocity drops to nearly or quite one-half its former values. Except for the marked yearly changes in direction, no periodicity is recorded for the direction of the wind. During the northeast trade season this wind overpowers all local winds, and during the so-called "monsoon" season there is no marked indication of a daily land and sea circulation or change of direction, such as may often be observed along the coasts of larger land areas. In wind velocities, however, there is found to be a fairly well-defined daily, as well as seasonal, period.

From a comparison of the six daily readings of wind velocities, as carried on through the year, it may be concluded that in general there is a daily minimum velocity at about 4 a. m., and a daily maximum between 12 noon and 4 p. m. The velocity generally increased rapidly up to noon or early afternoon and then fell much more slowly to 8 or 9 p. m. Sometimes there seems to have been a secondary maximum occurring at about midnight, but this was not a regular feature of the daily variations in velocity. Similar early morning minima and mid-day maxima occur throughout the temperate and tropical zones, and their origin was long since explained, first by Espy and independently by Koeppen, as due to the diurnal variation in the vertical circulation of the atmosphere.

STORMS.

The old writings about the Marianas Archipelago show that, besides heavy rain squalls, the islands are sometimes [illegible]ited by storms similar to the West Indian hurricanes, known in the [illegible] Sea as "typhoons." Such storms, although comparatively r[illegible] the Marianas, [illegible]quently pass across the seas north or so[illegible]se islands. A[illegible]ing to Lieutenant Safford's notes, alre[illegible]red to, pages [illegible] 23, it seems that no such storm was

Guam during the seven years 1893 to 1900, but that during the years from 1850 to 1875, 15 typhoons or hurricanes were experienced at Guam, 8 of them occurring in the month of November, 2 in February, 3 in April, and 1 (each) in June and September.

In an article on "Guam and its people,"[a] Lieutenant Safford writes: "Hurricanes may occur at almost any time of the year. They may be expected at the change of the monsoons and are most frequent in the months of October and November. They are often of such violence as to blow down the greater part of the native houses, laying waste the maize and rice fields, uprooting or breaking off cocoanut trees, destroying the bread-fruit crop, tearing to shreds plantains and banana plants, and killing fowls and cattle. Vessels at anchor in the harbor are frequently swept from their moorings and cast upon the reef, as the letter-books of the Spanish governors of the island will show."

The records do not show that during the year 1902 the islands were directly visited by the full force of a typhoon, but we find that in May a typhoon passed by to the south of the island, causing variable winds during the 22d and 23d, and a heavy surf from the northwest in the harbor of San Luis d'Apra. In July two such storms passed south of the islands, and in August three days of high average wind velocities were interpreted by the islanders as being days when such atmospheric disturbances passed near them. September and October, 1902, each had one such recurrence of typhoons whose centers passed not very far, i. e., within 75 miles south of the coast. By examining the Philippine records it has been possible to verify all these stormy days at Guam as days on which typhoons should have passed near the island.

Bergholz's studies into the storms of the Far East,[b] and the map accompanying his book, show that most of the typhoons first appear in about the latitude and longitude of the Marianas, or just to the eastward. It is evident that a competent weather service on the Marianas and good telegraphic communication with the Philippines would do excellent service to the latter islands by making it possible to predict the approach of a typhoon, and to make some estimate of its violence.

[a] Safford, W. E., American Anthropologist, 1902 (N. S.), IV, pp. 708-709.
[b] Bergholz, P., Die Orkane des fernen Ostens. Bremen, 1900.

TABLE I.—*Temperatures at Agaña, Guam, in 1902.*

[Station: United States naval station. Means $=\frac{1}{4}(7_a+2_p+9_p+9_p)$.]

	7 a. m.		2 p. m.		9 p. m.		Means.		Absolute maximum.		Absolute minimum.		Mean daily range.	
1	2		3		4		5		6		7		8	
1902.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.
January	76	24.4	83	28.3	78	25.6	79	26.1	86	30.0	70	21.1	8	4.4
February	77	25.0	83	28.3	79	26.1	80	26.7	86	30.0	71	21.7	8	4.4
March	77	25.0	84	28.9	79	26.1	80	26.7	87	30.6	72	22.2	10	5.6
April	80	26.7	84	28.9	80	26.7	81	27.2	87	30.6	73	22.8	8	4.4
May	80	26.7	86	30.0	81	27.2	82	27.8	88	31.1	72	22.2	9	5.0
June	81	27.2	86	30.0	81	27.2	82	27.8	90	32.2	73	22.8	10	5.6
July	78	25.6	85	29.4	80	26.7	81	27.2	90	32.2	75	23.9	9	5.0
August	79	26.1	84	28.9	80	26.7	81	27.2	88	31.1	74	23.3	9	5.0
September	79	26.1	83	28.3	79	26.1	80	26.7	87	30.6	73	22.8	11	6.1
October	77	25.0	84	28.9	79	26.1	80	26.7	88	31.1	70	21.1	10	5.6
November	77	25.0	82	27.8	78	25.6	79	26.1	85	29.4	69	20.6	11	6.1
December	75	23.9	82	27.8	77	25.0	78	25.6	85	29.4	66	18.9	9	5.0
Maximum	81	27.2	86	30.0	81	27.2	82	27.8	90	32.2	75	23.9	[a]17	9.4
Minimum	75	23.9	82	27.8	77	25.0	78	25.6	85	29.4	66	18.9	[b]3	1.7
Mean	78	25.6	84	28.9	79	26.1	80	26.7	87	30.6	72	22.2	9	5.0

[a] June 23, 1902. [b] November 10, 1902.

TABLE II.—*Rainfall at Agaña, Guam, in 1902.*

	Total.		Percentage of annual.	Maximum in 24 hours.		Number of days. Total.	>0.10″.	>0.5″.	>1.0″.	Rain intensity.
	1		2	3		4	5	6	7	8
1902.	*In.*	*Mm.*		*In.*	*Mm.*					
January	3.58	90.93	3.1	1.01	25.65	18	11	2	1	2.0
February	7.30	185.42	6.3	2.24	56.90	21	9	4	3	3.5
March	3.21	81.53	2.8	0.90	22.86	16	9	2	0	2.9
April	3.87	98.04	3.3	0.71	18.03	19	11	3	0	2.0
May	4.55	115.57	3.9	0.92	23.37	22	9	3	0	2.5
June	7.14	181.36	6.1	2.92	74.17	25	12	4	1	2.9
July	16.06	407.92	13.8	6.26	159.00	28	17	7	5	5.7
August	19.72	500.89	16.9	4.72	119.89	28	23	12	4	7.0
September	27.01	686.06	23.2	5.31	134.87	27	26	15	8	10.0
October	9.63	244.60	8.3	2.81	71.37	21	12	7	3	4.6
November	11.86	301.24	10.2	2.62	66.55	25	17	6	4	4.7
December	2.53	64.26	2.2	0.77	19.56	15	9	1	0	1.7
Sum	116.46	2,958.12	100.0	......	....	265	165	66	29	4.4
Maximum	27.01	686.06	23.2	6.26	159.00	28	26	15	8	10.0
Minimum	2.53	64.26	2.2	0.71	18.03	15	9	1	0	1.7

TABLE III.—*Comparative monthly and annual rainfalls in 1902.*

Month.	Philippines.	New Guinea.	Guam (Agaña).	Month.	Philippines.	New Guinea.	Guam (Agaña).
	cm.	*cm.*	*cm.*		*cm.*	*cm.*	*cm.*
January	10.0	20.0–30.0	9.0	August	20.0	10.0	50.0
February	30.0	30.0–40.0	18.5	September	30.0– 40.0	20.0– 30.0	68.6
March	20.0	20.0–30.0	8.2	October	20.0	20.0	24.0
April	10.0–20.0	30.0–40.0	10.0	November	20.0	20.0	30.0
May	20.0	10.0–20.0	11.6	December	10.0– 20.0	30.0– 40.0	6.4
June	20.0	20.0	18.0				
July	10.0–40.0	10.0–30.0	41.0	Year	220.0–290.0	250.0–310.0	295.8

TABLE IV.—*Wind directions and velocities at Agana, Guam, in 1902.*

	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Variable.	Velocities (miles). Average daily.	Velocities (miles). Average hourly.
	1	2	3	4	5	6	7	8	9	10	11
January:											
Days	0	16½	11	2½	1	0	0	0	0	167.5	7.0
Per cent	......	53.0	32.0	8.0	3.0	....	......	....	....	....	....
February:											
Days	0	12	9½	6½	0	0	0	0	0	224.8	9.4
Per cent	......	43.0	34.0	25.0	......	....	......	....	....	....	....
March:											
Days	½	16½	12½	½	½	½	0	0	0	210.0	9.0
Per cent	2.0	53.0	40.0	2.0	2.0	2.0	......	....	....	....	....
April:											
Days	0	20	8	1½	0	0	0	0	0	257.5	10.7
Per cent	......	67.0	28.0	5.0	......	....	......	....	....	....	....
May:											
Days	0	13	14½	1½	0	0	0	0	2	212.0	9.0
Per cent	......	43.0	47.0	4.8	......	....	......	....	5.2	....	....
June:											
Days	0	6½	17	4½	1	0	0	0	1	225.0	9.4
Per cent	......	20.0	57.0	16.0	8.0	....	......	....	3.0	....	....
July:											
Days	0	13½	5½	6½	4	1	0	0	1	165.4	6.9
Per cent	......	43.0	18.0	21.0	13.0	2.5	......	....	2.5	....	....
August:											
Days	1½	1½	2½	5	6½	3	3½	1	6½	122.5	5.1
Per cent	4.5	4.5	8.5	16.5	21.5	9.5	11.5	2.5	21.5	....	....
September:											
Days	0	0	0	0	6	16½	5	2½	0	a 249.2	a 10.4
Per cent	......	......	......	......	20.0	55.0	16.6	8.3	....	....	....
October:											
Days	0	4	10	3	6	1	1	0	6	162.5	6.8
Per cent	......	12.0	33.5	9.5	20.0	2.5	2.5	....	20.0	....	....
November:											
Days	4	6	14	½	3	0	½	0	2	237.2	9.9
Per cent	13.3	20.0	46.6	1.6	10.0	....	1.3	....	6.6	....	....
December:											
Days	2	8	21	0	0	0	0	0	0	225.7	9.4
Per cent	6.5	25.8	67.7	......	......	....	......	....	....	....	....
Sums, days	8	117	125	32	28	22	10	3½	18½	....	....
Per cent for year	2.0	32.0	37.0	8.0	7.0	6.0	2.0	1.0	5.0	....	....

a For 27 days continuous observation.

A CLIMATOLOGICAL DICTIONARY FOR THE UNITED STATES

By Prof. A. J. HENRY, U. S. Weather Bureau

The trend of meteorological thought and discussion in the United States during the last fifty years has been toward the elucidation of the problems of theoretical meteorology rather than those of climatology proper. Much material has been collected and studied with a view of discovering the underlying causes of storm development and the attendant phenomena, and of developing the utilitarian aspect of the science. The aim has been to furnish precise information as to probable weather changes for comparatively short periods—to deal with problems of weather rather than climate.

In the exploitation of the far West twenty-five years ago much energy and much capital were expended before it was discovered that the climate of the region was not well suited to the needs of agriculture. Fortunately the lesson thus learned was not lost. A demand for climatic data soon arose from prospective settlers in all parts of the country. At first a division of the central office of the Weather Bureau in Washington was created to respond to climatic inquiries, but in recent years climatic services have been organized in each State and Territory. The work of these services is conducted on a uniform plan, and the results are published monthly. A Bureau of Soils has also been created, whose object is the investigation of soils in their relation to crops, the mapping of soils, and the investigation, mapping, and reclamation of alkali lands; so that provision is now made by the United States Department of Agriculture for the study of the two great factors which determine the agricultural capacity of a region—viz, its soil and climate.

The especial purpose of this paper is to direct attention to the fact that a summary of the climatological work that has been done in this country is now in the course of preparation by the United States Weather Bureau, and to urge upon the members of the congress the

importance of the preparation of a similar work for the remainder of the inhabited portions of the globe. There can be no question as to the necessity for such a work. If the details of climate are not available, the broader features should be given for representative stations in each country. Verbal descriptions should be accompanied by quantitative statements, if we are to gain distinct conceptions of the different meteorological conditions. It is true that climatic observations have not yet been made in all countries, yet such observations as have been made are so widely scattered and in such form as to be practically useless to the average writer. In the United States, for example, climatological observations have been made for the greater part of a century, yet one is unable to find a comprehensive summary in any single volume.

That this state of affairs exists is not surprising when we consider that in this country meteorological observations have been conducted under various auspices and for widely different purposes. Some of the results of the chief series of observations are to be found in the following list of publications:

U. S. Army Meteorological Register, Washington, 1855.

U. S. Army Meteorological Register, Washington, 1860.

Results of meteorological observations made under the direction of the Patent Office and Smithsonian Institution, Washington, 1861.

Smithsonian contributions to knowledge, No. 277. Tables, distribution and variation in atmospheric temperatures in the United States, Washington, 1876.

Smithsonian contributions to knowledge, No. 353. Tables and results of precipitation in the United States, second edition, Washington, 1881.

Annual reports and other publications of the Signal Service and the U. S. Weather Bureau.

Only a small percentage of the publications named in the above list is now available to students and investigators. For this reason and others the United States Weather Bureau of the Department of Agriculture has in the course of preparation a census, so to speak, of the climatology of the United States. It is the intention to bring together in a single volume the available climatic statistics for each State and Territory. The State or Territory will be the geographic unit in the discussion, except that the New England States will be treated as a single climatic province, and the State of Delaware will be included with Maryland, with which it is associated by natural as well as climatic boundaries. The ultimate geographic unit for the United States must be the county. Unfortunately, however, climatological observations have not been made in more than probably 20 per cent of the existing counties.

The first chapter of this volume will treat of the broader features of climate, such as the temperature distribution, the character and amount

of precipitation, the prevailing winds, etc. The remaining chapters will deal with the climate of the several States and Territories, each district or political division being treated by the local representative of the Weather Bureau stationed therein. In all the records of about 600 stations will be used. Of this number about 130 are the so-called regular stations of the Weather Bureau, where rather complete observations are made of all the principal climatic elements. The observations at the remaining stations refer mostly to temperature and precipitation and the state of the sky.

A sample table, viz, that for Baltimore, Md., is given below to illustrate the character of the information contained in the work:

MARYLAND.

North Central division—Station: Baltimore.

[OLIVER L. FASSIG, section director, in charge.]

Established by Signal Service January 1, 1871; latitude, 39° 18′ north; longitude, 76° 37′ west; elevation (station barometer), 123 feet above mean tide.

This station is (1904) near the center of the city, in one of the buildings of the Johns Hopkins University.. The open country to the west and north of the city is gently undulatory, forming the eastern edge of the Piedmont Plateau; to the east is the low, flat country of the coastal plain.

The thermometers are mounted in a standard Weather Bureau shelter, the floor of which is 9 feet above the roof of the station building.

The following table shows the height of the instruments in their present location:

	Above roof.	Above ground.
	Feet.	*Feet.*
Thermometers	10	69
Top of rain gauge	14	73
Anemometer cups	58	117
Wind vane	56	115

Location of stations and elevation of barometer above mean tide:

January 1, 1871, southwest corner of South and Water streets, 45 feet.

January 1, 1889, Neal Building, southwest corner of Baltimore and Holliday streets, 76 feet.

June 1, 1891, Johns Hopkins University (physical laboratory), 179 feet.

September 7, 1895, Equitable Building, southwest corner of Calvert and Fayette streets, 142 feet.

August 1, 1896, Johns Hopkins University (532 N. Howard street), 123 feet.

The mean temperatures are derived from the regular series of observations of the Weather Bureau, to which corrections have been applied to reduce to true daily mean based on 24 hourly observations.

Monthly, seasonal, and annual means.

TEMPERATURE.

Month.	Mean.	Mean of the maxima.	Absolute maximum.	Mean of the minima.	Absolute minimum.	Highest monthly mean.	Lowest monthly mean.
	°	°	°	°	°	°	°
December	37	44	73	31	− 3	45	29
January	34	41	73	27	− 6	44	24
February	35	43	78	28	− 7	43	26
Winter	35	43	....	29	....	....	....
March	42	49	82	34	5	50	35
April	53	61	94	44	24	59	47
May	64	73	96	55	34	71	60
Spring	53	61	....	44	....	....	....
June	73	82	99	64	47	76	68
July	78	86	104	69	55	82	72
August	76	84	100	67	51	80	73
Summer	76	84	....	67	....	....	....
September	68	77	101	61	39	77	6[illegible]
October	58	66	90	49	30	64	5[illegible]
November	46	53	79	39	15	52	4[illegible]
Autumn	57	65	....	50	....	....	....
Annual	55	63	104	47	− 7	....	....

PRECIPITATION.

Month.	Mean.	Number of days with 0.01 inch or more.	Total amount for the driest year.	Total amount for the wettest year.	Snow.	
					Greatest depth in 24 hours.	Average depth.
	Ins.		*Ins.*	*Ins.*	*Ins.*	*Ins.*
December	3.1	11	2.1	0.6	10.6	3.3
January	3.2	12	2.1	4.2	7.0	5.6
February	3.7	11	4.6	2.5	15.5	7.5
Winter	10.0	34	8.8	7.3	....	16.4
March	4.0	13	3.2	5.7	12.0	5.8
April	3.3	11	2.1	8.7	8.0	0.8
May	3.6	12	1.0	6.8	T.	T.
Spring	10.9	36	6.3	21.2	....	6.6
June	3.8	10	4.3	6.2	0.0	0.0
July	4.7	12	1.5	11.0	0.0	0.0
August	4.2	11	2.9	1.4	0.0	0.0
Summer	12.7	33	8.7	18.6	....	0.0
September	3.8	9	4.3	4.6	0.0	0.0
October	3.0	9	1.7	4.1	T.	T.
November	3.0	10	1.8	6.4	4.5	0.8
Autumn	9.8	28	7.8	15.1	....	0.8
Annual	43.4	131	31.6	62.2	15.5	23.8

Monthly, seasonal, and annual means—Continued.

HUMIDITY AND SUNSHINE.

Month.	Mean humidity.				Total sunshine.		Direction of prevailing winds.
	Relative, 8 a. m.	Absolute, 8 a. m.	Relative, 8 p. m.	Absolute, 8 p. m.	Average hours.	Percentage of possible.	
	Per cent.	*Grs.*	*Per cent.*	*Grs.*	*Hrs.*	*Per cent.*	
December	74	1.75	68	1.87	159	50	W.
January	75	1.52	69	1.57	162	50	W.
February	73	1.48	67	1.53	179	59	W.
Winter	74	1.58	68	1.66	167	53	W.
March	71	1.38	65	2.06	211	57	NW.
April	65	2.56	60	2.91	237	60	SE.
May	68	4.04	65	4.41	239	54	SE.
Spring	68	2.83	63	3.13	229	57	SE.
June	70	5.77	68	6.16	276	62	SW.
July	72	6.74	68	6.99	282	62	SW.
August	73	6.41	69	6.66	267	63	SW.
Summer	72	6.31	68	6.60	275	62	SW.
September	76	5.15	73	5.64	243	65	SE.
October	74	3.47	69	3.58	211	60	SE.
November	75	2.38	69	2.53	165	51	W.
Autumn	75	2.67	70	3.92	206	59	SE.
Annual	72	3.60	68	3.83	219	58	SE.

Dates of temperature extremes for the period January 1, 1873, to December 31, 1903.

[Mean of minima for the coldest month, 27°; mean of maxima for the warmest month, 86°; absolute minimum, —7°, 1899; absolute maximum, 104°, 1898.]

Year.	Dates when minimum temperature fell to or below 10°.	Dates when maximum temperature rose to or above 95°.
1873	Jan. 29-31; Feb. 24; Mar. 4, 5	June 20; July 3, 18.
1874		June 8, 9, 23, 29; July 10; Aug. 20-21.
1875	Jan. 9, 10, 11; Feb. 8, 9, 10, 15, 16, 18	June 24-27; July 18.
1876	Dec. 9, 10, 17, 19	June 27; July 4, 8-13, 20.
1877	Jan. 1, 3-6; Mar. 18	June 26.
1878	Jan. 8	July 18, 19, 21.
1879	Jan. 2-5	July 3, 4, 11, 16.
1880	Dec. 29-31	June 12, 24; July 10, 13.
1881	Jan. 1, 3; Feb. 2, 3	May 13; July 5, 6, 13; Aug. 13; Sept. 7.
1882	Jan. 24; Dec. 8	June 25.
1883		July 22, 23.
1884	Jan. 6, 7; Feb. 29; Dec. 19, 20	July 24.
1885	Jan. 22; Feb. 1, 17, 20, 21	June 14; July 17, 18, 20, 21, 25.
1886	Jan. 10-15; Feb. 4-6	
1887	Jan. 3, 19	July 13, 14, 16-18.
1888	Jan. 22, 28	Aug. 16.
1889	Feb. 24	
1890		July 8, 17, 31; Aug. 1.
1891		
1892		July 25-29; Aug. 9, 10.
1893	Jan. 10, 11, 13-16, 18, 22	June 20; July 26.
1894	Feb. 25; Dec. 29	June 23, 24; July 12, 13, 20, 28, 29.
1895	Jan. 13; Feb. 3, 5-9	May 30, 31; June 1-3; July 21; Aug. 10, 11; Sept. 21-23.
1896	Jan. 5, 6; Feb. 17, 18, 20	May 10; July 27; Aug. 5, 7, 9, 11, 12.
1897	Jan. 25, 26	June 30; Sept. 11.
1898	Feb. 2	June 25, 26; July 1-4; Aug. 31; Sept. 1-3.
1899	Jan. 1, 2, 11; Feb. 1, 8-15; Dec. 30, 31	June 6-8; July 22; Aug. 20, 27.
1900	Jan. 31; Feb. 1, 2, 24, 25, 27	July 4, 6, 7, 15-18, 21; Aug. 6-12; Sept. 11.
1901		June 29-30; July 1-4, 6, 29, 30.
1902		July 3, 5, 6, 17, 18, 20.
1903	Feb. 18, 19	July 2, 3, 9-11, 30; Aug. 25.

SUMMARY.

Temperature.—Mean annual, 55°; mean maximum, 63°; mean minimum, 47°. Absolute maximum, 104°; absolute minimum, —7°. Average number of days with maximum above 90°, 17; with minimum below 32°, 69.

Frost.—Average date of first killing frost in autumn, November 5; last killing frost in spring, April 4. Number of times in thirty-three years that the first killing frost occurred one to ten days previous to the average date, 12; eleven to fifteen days previous, 2; sixteen to twenty days previous, 1. Number of times in thirty-three years that the last killing frost occurred one to ten days after the average date, 9; eleven to sixteen days after, 2; sixteen to twenty days after, 2. Date of earliest killing frost known, October 6, 1892; latest killing frost known, May 3, 1882.

Precipitation.—Mean annual, 43.4 inches; spring, 10.9; summer, 12.7; autumn, 9.8; winter, 10.0.

Wind (miles per hour).—Mean hourly velocity, 5.8 (1879–1888, South and Water streets; elevation of anemometer cups, 86 feet above ground).

Dates when the maximum velocity equaled or exceeded 40 miles per hour, and direction.

Year.	Date.	Velocity.	Direction.	Year.	Date.	Velocity.	Direction.
		Miles.				*Miles.*	
1873	Mar. 29	40	S.	1898	July 26	42	NW.
1874	Nov. 23	40	NW.	1893	Aug. 29	42	SE.
1876	Feb. 2	40	NW.	1893	Oct. 13	40	SE.
1878	Oct. 23	45	SW.	1894	Jan. 30	48	W.
1878	Dec. 11	40	W.	1894	Feb. 16	42	NW.
1879	Apr. 3	60	NW.	1894	June 12	40	N.
1888	Aug. 8	45	SW.	1895	Feb. 8	42	W.
1891	June 4	40	NE.	1895	Dec. 26	42	S.
1891	Nov. 17	40	NW.	1896	Feb. 6	40	W.
1891	Nov. 23	48	S.	1896	Feb. 11	40	W.
1891	Dec. 16	40	NW.	1896	Mar. 19	50	S.
1892	Mar. 10	42	NW.	1898	Dec. 4	54	E.
1892	June 27	42	SW.	1902	July 20	70	W.
1892	Nov. 15	42	NE.	1903	Jan. 30	42	W.
1892	Nov. 18	42	NW.	1903	Feb. 5	45	W.
1893	Feb. 3	42	NW.	1903	July 12	46	W.
1893	Feb. 19	45	NW.	1903	July 30	42	W.
1893	Feb. 24	40	NW.	1903	Oct. 9	42	N.
1893	Apr. 15	42	NW.	1903	Dec. 13	41	NW.
1893	May 4	40	NW.	1903	Dec. 26	40	NW.
1893	May 23	43	W.				

Miscellaneous phenomena.—Average number of days with fog, 12 (1891–1903); hail, 2 (1876–1903); snow, 12 (1871–1903); thunderstorms, 22 (1893–1903).

The completion of the work, which is expected during the summer of 1905, will only partially meet the demands of geographers and others. A similar work is needed for all other portions of the civilized world, and the hope is expressed that the delegates to this congress will extend their aid and influence toward the accomplishment of such a desideratum.

SCIENTIFIC WORK OF MOUNT WEATHER METEOROLOGICAL RESEARCH OBSERVATORY

By Prof. FRANK H. BIGELOW, U. S. Weather Bureau

Meteorology has for its field of study the physics of the earth's atmosphere. Since all stellar and planetary atmospheres are subject to similar laws, meteorology properly is concerned with astrophysical and solar physical problems as well as with terrestrial atmospheric relations. Cosmical meteorology may be used as a term to designate the mutual relations between solar and terrestrial atmospheric physics. The causes of the circulation of the earth's atmosphere are intimately bound up with the causes of the circulation of the sun's atmosphere. The generation of the great cyclonic circulation in the earth's atmosphere covering a hemisphere is due to the sun's radiation falling upon the Tropics, and the tendency to return to a thermal equilibrium is accompanied by the production of local cyclones and anticyclones in the middle latitudes of the northern and southern hemispheres. Similarly, the sun's own circulation can be divided into a general drift over the hemisphere and a series of minor or local gyrations in different latitudes. We have shown in a paper that three aspects of one common law of general motion are mathematically competent to account for the three typical drifts, within which the local storms occur as secondary phenomena. The solar energy pours forth in several types of radiation, and these are accompanied by various kinds of surface phenomena which are subject to our observation. Their interpretation is to be made in terms of the general solar action, and they are to be treated as pulses or symptoms of the great operations inside the solar surface, whose laws can be discovered only by inference and mathematical analysis. The immediate signs of the internal solar action are the frequency of the occurrence of the black-spotted areas which vary from year to year, the relative abundance of the faculæ and the flocculi, the granulations of the photosphere, the numerical frequency of the hydrogen and calcium prominences which are projected to considerable distances above the disk, and in the form and extent of the solar corona. We now know that the period of rotation in different zones

and the frequency of all these phenomena vary from year to year in at least three fundamental cycles, whose lengths are, respectively, about thirty-five years, eleven years, and three years. The records disclose two or three thirty-five-year cycles, more than twenty eleven-year cycles, and a great number of three-year cycles. We have in hand the typical annual curves of these in about all the phenomena mentioned, and they certainly constitute a single homogeneous system, as they apparently ought to do, since they are various kinds of registers of the same solar action.

Beyond the surface of the sun there are several types of radiation which transport the solar energy into distant cosmical spaces. The most conspicuous is the electro-magnetic radiation, whose energy is practically confined to wave lengths from 0.35 μ to 2.50 μ, of which the waves up to 0.8 μ are visible, while all the others are invisible to the human eye. The other waves, ultra violet and infra red, are detected through appropriate physical observations, by photography, bolometry, and by spectroscopy. There are also generated at the surface of the sun certain electrical radiations, like the cathode rays in a vacuum tube where positive and negative charges of electricity are transported by ions into space, and these are seen in the long coronal streamers, possibly also in the zodiacal light at the earth. There are weighty reasons for thinking that the sun, like the earth, though having a very high interior temperature, yet sustains a magnetic field which embraces the earth in its operations.

At the earth the effect of these solar forces is registered by the changes observed in the aurora and the magnetic elements. The solar annual curve, which is conspicuously found in the prominences, is reproduced in the earth's magnetic field. It is also found in various portions of the earth to reappear in the barometric pressure and temperature, in the rainfall and the intensity of storms. This signifies that the changes in the internal circulation of the sun reach over to the earth and induce synchronous changes in the circulation of our atmosphere. The several impulses mentioned, whether solar or terrestrial, throughout which this synchronism has been traced, are merely symptoms of the great cosmical circulation extending from the sun out into space and involving the planets more or less vigorously. The earth is near enough to the sun to feel the changes of the solar circulation in a very definite manner. There are a few hundredths of an inch of annual pressure involved and two or three degrees of temperature are concerned.

When we consider that the annual values are made up of a great number of short oscillations of the atmospheric conditions at a station, we have the means for interpreting them in terms of climate. The amplitudes of the pressure and temperature oscillations change decid-

edly from one year to another, and we note the result popularly by the fact that one winter is cold and the next warm, one summer dry and another moist. These practical results are always accompanied by certain changes in the normal conditions—that is to say, their departures from the normal or average state of the temperature. We now know that some countries are favorable and some unfavorable for recording the solar variations in terms of meteorological changes. Generally the plateau and mountainous regions are not as well adapted as the low-level or oceanic areas to feel this solar impulse without mixing it up with the other motions of the atmosphere and burying it in them. Thus Asia is not favorable, Europe and Africa are somewhat better, while North and South America, the Indian Ocean, and Australia are the most sensitive areas for making the records. The small ocean islands, Mauritius, Azores, Hawaii, etc., seem to be most suitable for this solar registration. This is, no doubt, due to the fact that the ocean-island climates are less disturbed than the continental, where the mountain ranges exercise a great influence upon the circulation of the lower strata of the atmosphere. Thus the Himalaya Mountains, stretching east and west, shield the continent of Asia from cyclonic action, while the Andes and the Rocky Mountains, stretching north and south, are favorable for producing local storms in North and South America. The Indian Ocean records the solar impulse in one way by reason of the quiescence of the atmosphere over it, while the United States records it in another way by reason of the activity of the circulation traversing it. This region has many more storms than other portions of the earth, and that is why meteorology has a special duty to perform for science in the United States by reason of its active field, which favors a proper study of the fundamental problems.

Enough has been accomplished in the way of establishing the fact of this solar-terrestrial synchronism to justify scientific men in all portions of the earth in devoting their best energies to a further elucidation of all the facts. The range of work is enormous, since it involves so many lines of correlated subjects in solar physics, terrestrial magnet ism, and meteorology.

The international meteorological committee is about to organize a strong attack upon the cosmical problem by enlisting the cooperation of observatories in these several fields of work, both as to the method of observations and the mode of computation and publication. This alliance between solar physics and meteorology is most desirable, and there is little doubt that the foundations will be laid for a great practical science, whose outcome, we hope, will be an ability to forecast the seasonal conditions at least approximately from year to year. The benefits to be derived by the American public from a fair knowledge

of the probable kind of seasons to be expected in the several portions of the country is so obvious that a generous support of the scientific work required to reach this result will seem not only permissible, but most important. How rapidly a practical conclusion for such studies can be reached will depend almost entirely upon the facilities placed at the disposal of the Weather Bureau by the Government. It will require able students to handle the technical problems and many workers to carry out the details of the observations and make the necessary computations. The Secretary of Agriculture and the Chief of the Weather Bureau have been making preparations for this work by founding a research meteorological observatory at Mount Weather, Bluemont, Va., about 65 miles northwest of Washington. The site contains 85 acres of land, located on the crest of the Blue Ridge Mountains, 1,800 feet above sea level, and overlooking the Piedmont and the Shenandoah valleys. It is far enough away from any probable trolley line, such as one through Snickers Gap, to escape the electric currents which might injure the magnetic observations. The rocks are nonmagnetic to a remarkable degree, and the magnetic field is uniform, so that the place is a good one for the observatory. We have a large building for administration and common meteorology already completed, a fine balloon and kite plant in process of construction, and operations have been begun on a first-class variation and absolute observatory for atmospheric magnetism. Plans are being studied for an excellent physical laboratory to accommodate experiments in meteorological physics, in the improvement of instruments, in atmospheric electricity, ionization and radio-activity of the air and of soils, and other research investigations. We are working out a comprehensive scheme for a solar physics observatory for studying the visible signs in the sun spots, prominences, faculæ, and photosphere by a photographic telescope, a horizontal spectro-heliograph, and a spectrum analyzer; also, it will contain a high-grade bolometer if the site proves sufficiently favorable for this line of radiation observations. There are numerous small pieces of auxiliary apparatus which will be developed and added as time and experience suggest.

To coordinate and organize so large a scientific plant will require time and money, but it is felt that we can in no other way suitably serve the American public in this branch of science. While there is similar work of the kind going on in different parts of the world, it is not possible for us to make use of it in practical forecasting. Except for some preliminary notices of results to be found in current scientific journals, the published reports are usually delayed two or three years behind the date of the observations. Furthermore, coming from so many sources, different countries, and different observers, the data are not homogeneous. It takes so much time and labor to work over

and render comparable this miscellaneous material that it is better to bring all the necessary lines of study under one management and make the observations and computations homogeneous from the beginning, so as to keep the data in form for immediate deductions regarding the trend of the general meteorological conditions in the United States. We are looking to the future needs of a rapidly developing and intensely interesting branch of science, and are trying to build the the very best observatory possible. We shall seek to equip it with the most satisfactory instruments which are available. There will be no haste in order to reach sensational forecasts, and it is believed that the public will indorse the strictly scientific method here outlined.

SUGGESTIONS CONCERNING A MORE RATIONAL TREATMENT OF CLIMATOLOGY

By ROBERT DE C. WARD, Harvard University

It is the chief duty of the present writer to give college students of various classes some instruction in climatology, as a part of their general education, rather than to train them to become professional workers in meteorology. It is, therefore, his constant endeavor to give as vivid an idea as possible of the climates and weather of the different parts of the world, and to emphasize in every way the relations of climate to man, in the control of habitability, occupations, travel and transportation, customs, migrations, history, and the like. In the effort to present this lifelike picture of climate every possible source of information is drawn upon, but the basis of the discussion must be the usual tables of climatological data, whenever such data are available. The conventional method of setting forth the facts by means of these tables and such verbal statements as usually accompany them is, however, not altogether satisfactory, and it is the purpose of this paper to make one or two suggestions along the line of a more rational treatment of local climatology.

The object of climatology is to make us familiar with the average conditions of the atmosphere in different parts of the world. It is, however, recognized that the departures need consideration, as well as the averages. A full description of a climate is given when certain numerical data, carefully corrected, summarized, and compared by well-known methods, are tabulated in a conventional form. These data, enumerated by Hann in his Handbuch der Klimatologie,[a] are so familiar to students of climatology that they need not be listed here. On such data climatic accounts are based. Loose, generalized, verbal statements do not constitute scientific climatology. On the other hand, when the proper tabular data are given, well-considered verbal descriptions are not only perfectly admissible, but are essential to a proper presentation of the subject. Publications consisting wholly of tabulated data concerning the climate of a locality—and the mail brings many such, of large size and great weight—however carefully the

[a] Vol. I, 2d ed., 1897. Translated by R. DeC. Ward. New York, Macmillan, 1903.

original observations were made, however laboriously and critically the summaries were compiled, and however essential such a purely numerical and statistical substructure is, can not fail to appear lifeless and incomplete to the teacher of climatology, whose duty it is at once to use these data in giving an interesting picture of the climate of the region considered. Verbal descriptions, with emphasis on the living side of climate, are absolutely indispensable. In the past climatology has been too much concerned with averages, and too little concerned with the units, i. e., the individual weather changes which go to make up the average. These changes, being actually experienced from day to day, and affecting man's activities, his crops, his health, his mode of life, are of the greatest interest and importance to him.

Over the greater portion of the equatorial zone weather and climate are almost synonymous terms. There the usual climatic tables, giving daily, monthly, and annual means and ranges, are on the whole perfectly satisfactory. That zone is characterized by extraordinary regularity in the sequence of its diurnal weather changes. Cyclones occur in small numbers over limited districts and at certain seasons only. They are, it is true, accompanied by heavy rainfalls which may send the hourly, daily, monthly, or even annual means above the usual averages for those periods, but the cyclonic temperature changes are not marked. The cyclonic unit is therefore of little importance in tropical climatology.

In the so-called "temperate" zone, and in the polar zone, conditions are quite different. The regular diurnal changes are very frequently overshadowed by the larger irregular changes which are due to the passage of cyclones and anticyclones. The latter being irregular in their occurrence, uncertain in their progression and duration, and differing greatly in their characteristics, the weather changes must be correspondingly irregular, uncertain, and diverse. The essence of the cyclonic control being its irregularity, it is obvious that the cyclonic effects must very largely disappear when the usual time units are taken as the basis for averaging climatic data. Thus the usual means, the ranges, the extremes, for a day, a month, a year, can not adequately emphasize the irregular cyclonic changes in the different elements, and yet these very changes are of the greatest importance in their effects on man, and really give a climate its character.

A few illustrations will make this clear. Take the case of the mean diurnal range of temperature, which may be based on the difference between the maximum and minimum temperatures of each day (non-periodic range), or on the difference between the mean temperatures of the warmest and coldest hours (periodic range). Many differences, some larger and some smaller, make up the mean difference between the maximum and minimum daily temperatures, the individual differences being merged in this mean. Now, a diurnal range of tempera-

ture may result from the difference between a low early morning minimum after a clear, quiet, anticyclonic night, and a succeeding high afternoon maximum under strong insolation; or from the difference between the moderately high temperature registered during a warm, damp, southerly wind in front of an advancing cyclone, and the succeeding cold brought by the northwest wind on the rear of the same cyclone. In the first case the control is diurnal; in the latter, cyclonic. The range may be the same in the two cases, but the controls, the other accompanying weather conditions, and the physiological effects are very different. The cooler morning and night noted in connection with the regular rise and fall of the typical diurnal variation of temperature, under solar control, can be easily avoided by delicate persons who remain indoors during all but the warmest hours of the day. The cyclonic changes, on the other hand, are irregular, uncertain, and often very sudden; they may come at any time of day or night; can not be definitely foretold, and are accompanied by winds which may have unpleasant physiological effects. So different are all the conditions in the two cases, that, as has been suggested by another, the diurnal variation of temperature due to solar control may be termed the diurnal range, and that due to cyclonic control, the diurnal change. Any complete presentation of the climate of a region in which the cyclonic control is of such importance should include the average values of the cyclonic changes of temperature for each month and for the year, in addition to those of the general mean diurnal range. When we have the typical diurnal curve, with a single maximum and a single minimum, the readings of the maximum and minimum thermometers give the true diurnal range. It is, furthermore, clear that in the winter of the higher latitudes, when the cyclonic control is most marked, the nonperiodic mean diurnal range must include the extremes of the high and low temperatures brought at irregular hours by cyclonic winds, and that, under these conditions, the difference between the mean temperatures of the warmest and coldest hours (periodic mean diurnal range) is less than the former. In our winters, therefore, the mean variation of temperature produced by the solar control is to be found in the periodic mean diurnal range. At Blue Hill Observatory, Milton, Mass., for example, the mean temperature of the coldest hour in December, 7 a. m., is 25.7°, and of the warmest hour, 2 p. m., 32.4°, which gives a periodic mean diurnal range of 6.7°. On the other hand, the difference between the daily maxima and minima, i. e., the nonperiodic range (37.4° and 22.3°), is 15.1°.

In the Tropics the curious condition exists that the mean monthly ranges of temperature often differ very little from the mean diurnal ranges. Further examples of the varying relations between diurnal

and cyclonic temperature controls will be given in the curves at the end of this paper.

In the mean monthly and mean annual ranges of temperature, likewise based as they are on readings of the maximum and minimum thermometers, and hence properly designated as nonperiodic, we really have the sum of both periodic and nonperiodic changes, for these ranges obviously include all differences of temperature, however produced, which occur during any month. But to add together and then obtain the mean of all the daily maxima and minima for a month, without paying any attention to the question whether these maxima and minima all occurred under similar conditions, is to lose sight of a very important factor in climate.

The mean variability of temperature from day to day is an element of special importance to invalids, who need to know to what amount of change of temperature they are likely to be exposed from one day to another. This variability may be controlled by the difference in temperature from day to day under solar control, in which case it is small; or, as in extra-tropical latitudes, it may result chiefly from differences in temperature produced by cyclonic importations of heat and cold. Moreover, it makes a difference in the resulting physiological effects whether it is produced in one way or the other. The large diurnal variability of temperature which characterizes the greater portion of the United States is due to the frequency and rapid progression of its cyclones and anticyclones. Eastern Siberia has a small diurnal variability of temperature in winter because of the permanent anticyclonic control of that region at that season, while the variability increases toward the western part of the country because of the increasing frequency of cyclones there.

The mean temperature of any month often varies considerably from year to year, especially in the continental climate of the North Temperate Zone. This variation is expressed by the mean variability of the monthly mean temperatures, an element of considerable importance, but in and of itself it offers no clue to the normal and abnormal weather conditions which produce a monthly mean temperature differing much or little from the general mean for that month. A good example of a marked cyclonic control of monthly mean temperatures, and of the interest which an understanding of this control lends to the study of climatic summaries, may be found in Prof. R. F. Stupart's paper on "The climate of Canada," published in the Scottish Geographical Magazine, Vol. XIV, May, 1898, page 76. In the region along the eastern base of the Rocky Mountains the seasons vary greatly from year to year with the varying positions of the cyclonic tracks. When the cyclones move farther south in some winters, the warm chinook winds do not blow and the mean temperatures are low; when, in other years, the cyclones move farther north over northern British Colum-

bia, chinooks are the rule, and mild weather prevails. In January, 1886, Edmonton had a mean temperature of $-13.4°$, while in January, 1889, it had $21.9°$. In February, 1887, the mean was $-10.4°$, and in February, 1889, $21.9°$; in November, 1896, the mean temperature was $0°$, and in November, 1890, it was $38°$. The differences in these cases were due to the difference in the positions of the cyclonic tracks, and in the cyclonic control over winds and temperatures thereby brought about.

Precipitation is another element in which the introduction of the cyclonic unit would be of help in giving a more rational conception of climate. The most important conventional precipitation data include the monthly and annual means. These means, however, give no clue to the origin of the precipitation. Data concerning the proportion of the total monthly or annual rainfall which comes from cyclones of different types, or from thunderstorms, would greatly help to an understanding of the real physical conditions of a climate. Even in the Tropics, where the cyclonic unit is of little importance, it would be a distinct addition to the usual climatic tables of districts within the tropical cyclone belts if records were kept of the rainfall which falls in individual cyclones, rather than merely the total amount in any one day or month or year. Attention has not yet been paid to the cyclonic distribution and amount of rainfall in the tropical cyclone belts, although a large part of the total monthly precipitation of such a district may come in one cyclone. The inclusion of the cyclonic unit of rainfall in regions where a part or all of the rainfall is cyclonic, makes clear the immediate causes of the variation of rainfall in the same month in different years. These monthly variations of rainfall are very considerable in many regions, under the control of the varying numbers and tracks of the rain-bearing cyclones. An illustration cited in Greely's "American weather," page 143, comes to mind. In September, 1877, when three cyclonic centers passed over the South Atlantic States, the average rainfall for the district was 9.47 inches, while in September, 1886, when no storm center passed over the region, the average rainfall was less than one-fifth (1.84 inches) of that in the former year.

Further, in the data concerning the maximum precipitation per day, per hour, and per minute; the number of rainy days; the mean frequency of days with precipitation of a certain amount; the mean frequency of long dry and rainy periods; the frequency of different wind directions; the total monthly wind movement, and so on, averages in which some consideration of the cyclonic unit could be included, in addition to the general means, would help much in a proper understanding of climate. In the case of cloudiness, again, which should be recorded three times daily, and the monthly means given for each of the three hours, we have both diurnal and cyclonic clouds. The dis-

tinction between these two could in most cases be noted without difficulty, and could be indicated in the monthly means. Such data would be useful in explaining variations in cloudiness at different seasons and in different parts of a country. Thus, in the United States, for example, the greater cloudiness over the Great Lakes than in Arizona results chiefly from the fact of the situation of the Lakes with reference to the main cyclonic tracks, and the greater cloudiness of winter than of summer in this same lake region is due to the greater number and better development of the cyclones in the former season.

It is worthy of note that in the conception and treatment of climatology there has been a distinct tendency toward a fuller and more varied presentation of the elements of climate. Annual averages are no longer regarded as of the most essential importance; more and more attention is being paid to seasonal and monthly averages, to departures from the means, even to the single occurrence of certain phenomena. Averages, annual, and monthly are of great importance, and certainly have their place. Annual and monthly charts of temperature, winds, rainfall, etc., are based on such means. But means do not really represent the conditions which are actually experienced from year to year, or month to month, or day to day. There are, to be sure, years which are normal in respect to their mean temperatures, or rainfall, or cloudiness, but the abnormal, the extreme years and months or even days need just as much, or even more, attention. If a climate is to be thoroughly understood the characteristics of the typical normal, as well as those of typical abnormal or extreme periods, and the conditions of occurrence of such periods must be considered. Obviously, as the details of the meteorological conditions of individual months and days are entered into, the discussion goes beyond the limits of a strict definition of climate, and approaches a consideration of weather. If objection be made on this score, it may be urged that climatology rests upon meteorology; that a sharp dividing line can not be drawn between the two, and that if, to enliven and rationalize climatology, more of what is strictly termed meteorology is necessary, we should certainly not bind ourselves by a rigid definition.

It is fortunate for the development of this more rational treatment of climatology that in Bartholomew's new Atlas of Meteorology so much space is given to charts and discussions dealing with weather, these charts illustrating the pressure and weather conditions in abnormally hot and cold or wet and dry seasons in different months and in different regions, characteristic weather types, anomalous and typical weather and storms, storm tracks and distribution of storm frequency, etc. Valuable as such charts are, however, the full emphasis on the cyclonic control of the various weather elements which, taken together, make up climate, is not reached unless these elements are summarized on the basis, not of the year or month merely, but of the cyclone.

The importance of the cyclonic control has, of course, been generally recognized, and explicit statement is made of the cyclonic as differing from the diurnal, or monthly control, by several writers, as, for example, by Hann,[a] in connection with diurnal and monthly ranges of temperature, Davis,[b] and others, but the cyclonic unit is not specifically included in the standard tables of climatic data. In a review of the first edition of the Handbuch der Klimatologie, Professor Abbe[c] noted, as a desirable addition to the list of climatic data there given, the number of general storm centers that pass over a locality, and their geographical distribution, in view of the fact that "their frequency is directly indicative of the changeableness of the climate, and presents in one datum a very concise summary of the features that bear on health, business, domestic life, forestry, and commerce." Professor Abbe renews the suggestion in Volume I, pages 266–267, of the Maryland weather service.

Concerning this suggestion, there can be little hesitation in accepting the view which was expressed by Hann in his second edition,[d] when he says: "We fully agree with Abbe in believing that charts of the tracks of barometric minima, and of their frequency of occurrence upon these tracks, are a valuable aid in descriptive climatology. Such charts furnish direct evidence concerning the changeableness and the peculiarities of the weather at any definite place. Charts showing the distribution of storm frequency are therefore also of importance in determining the boundaries between climates. The frequency of weather changes from hot to cold and from cold to hot, as well as those from wet to dry, and vice versa, is an important climatic factor." But here again, while the cyclonic control is certainly clearly brought out on any charts showing the annual and monthly storm tracks and storm frequency, the actual value of the cyclonic variations in the different weather elements is not shown by them. Even in Meyer's invaluable discussion of the conventional methods, graphic and mathematical, of summarizing meteorological observations for use in the detailed study of local climatology,[e] the nonperiodic cyclonic and anticyclonic controls receive but brief consideration at the very end of the book, in the following statements (p. 175):

It is really through a study of cyclones and anticyclones that we may approach an understanding of the interdependence of the climatic factors, and * * * the cyclonic and anticyclonic changes, or, in other words, the changes in the distribution of pressure determine the climate of a country. It therefore suggests itself that in undertaking a description of the climate of any district the prevailing values of the climatic elements in different portions of cyclones and anticyclones should be deter-

[a] Handbook of climatology, pp. 13–14, 18.
[b] Elementary meteorology, passim.
[c] Ann. Rept. Smiths. Inst., 1883. Rept. on Met. Scientific Record for 1883, p. 491.
[d] Climatology, p. 83.
[e] Anleitung zur Bearbeitung meteorologischer Beobachtungen für die Klimatologie, 1891.

mined. The tracks of these great atmospheric whirls should be studied, *and the changes of the different climatic elements during the advance of these systems should be made out.*[a]

There have been a good many statistical studies of climate, with tabular and graphic treatment, and with the use of elaborate mathematical analyses and formulæ, but the study of this really live aspect of climate has been practically neglected, although a number of discussions, most of them undertaken from the meteorological rather than from the climatological side, have been contributions along these general lines. Thirty years ago Köppen made an important step in this direction.[b]

Other discussions of a more or less similar nature have come from Abercromby,[c] Krankenhagen,[d] Doerry,[e] van Bebber,[f] Leyst,[g] Akerblom,[h] and others.

The studies of weather types, important as such studies are, likewise do not bring out with sufficient emphasis and accuracy the actual values of the cyclonic variations of the different climatic elements.

In the United States the New England Meteorological Society, during the few years of its existence, made several distinct contributions to American meteorology, and among them a discussion along the lines here advocated.[i] This paper, although admittedly incomplete, based on the records of but a few years, and dealing chiefly with cyclonic variations of temperature only, may yet serve as a working model for descriptions of the actual variations of weather elements under cyclonic and anticyclonic control. The difference between a purely tabular or mathematical presentation of the climatic averages and the picture of the actual changes experienced from day to day, such as is presented in "Types of New England weather," is too obvious for comment. The weather types herein described might easily be increased in number, differing as they do with the season and with the character of the controlling pressure conditions, but the general scheme of presentation is one worthy of imitation. Other studies published under the auspices of the New England Meteorological Society have also placed an accent on the cyclonic unit. Thus Prof. Winslow Upton's "An Investigation of Cyclonic Phenomena in New England"[j] was an attempt to determine the peculiarities of the distribution of precipitation, not by months or for a year, but in dif-

[a] Italics are the present writer's.

[b] Ueber die Abhängigkeit des klimatischen Characters der Winde von ihrem Ursprünge: Repert. f. Met., IV, No. 4, St. Petersburg, 1874.

[c] Quart. Jour. Roy. Met. Soc., 1878.

[d] Met. Zeitschr., II, 1885, 81-99.

[e] Halle, 1889.

[f] Archiv d. Deutsch. Seewarte, XV, 1892, No. 4.

[g] Repert. f. Met., XVI, No. 8, 1893.

[h] K. Svensk. Vet.-Akad. Handl., Bd. 20, I, Stockholm, 1895.

[i] Types of New England weather: Annals Harv. Coll. Obs., XXI, Part II, 1890, 116-137.

[j] Amer. Met. Jour., III, 1886-87, 250, 316, 367.

ferent cyclones. A later paper[a] carried the same investigation farther and brought it down to a later date. In an earlier publication[b] the amounts of rainfall occurring in different special cyclones and the general cyclonic conditions under which these falls occurred had been taken up. There is a large field for further important investigation open along these same lines. Mr. H. H. Clayton's studies on the distribution of precipitation and of cloudiness around cyclones and anticyclones are also noteworthy investigations in this connection.[c] Attention should also be called to Dr. H. R. Mill's emphasis on the cyclonic control of heavy rains in the British Isles, as discussed in British Rainfall for 1903, pp. 132–153, with charts of rainfall distribution.

Summarizing what has been said, it seems to the writer, from the standpoint of a teacher of climatology, that the method of presenting climatic data in accordance with the usual scheme of tabulation is unsatisfactory because it does not bring out with sufficient emphasis the cyclonic variations of the different weather elements, and hence does not show the conditions as they are actually experienced from day to day, and as they affect man. No radical changes need be made in the present methods of tabulating and discussing climatic data in order to adapt them better to the purpose in hand. The usual tabular, graphic, and mathematical statements may be given as fully and as accurately as possible. No change need be made in the present recognized order of presentation, but whenever and wherever possible the cyclonic unit should be made the basis of summaries, as well as the diurnal, the monthly, the seasonal, and the annual unit. Much more attention should also be paid to an adequate verbal discussion. At present there is no recognized scheme of the verbal treatment which shall accompany the tabulated data.[d]

The controls of any given climate, as enumerated by Hann, should be presented as fully as possible. Of equal importance is the discussion of the conditions under which both normal and anomalous years, seasons, or months, and even days, occur, together with a well-considered rational description of the weather types, with illustrative typical weather maps and a statement concerning the simultaneous variations of all the different weather elements under typical and abnormal cyclonic or anticyclonic controls. The latter subject should, if possible, be illustrated by means of records from self-registering instruments.

In conclusion, reference may be made to a simple and effective

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[a] Cyclonic precipitation in New England: Ibid., XI, 1894, 241, 275.

[b] Heavy rainfalls in New England in 1888: Annals Harv. Coll. Obs., XX, Part I, 1889, 17-20.

[c] Annals Harv. Coll. Obs., Vol. XXX, part IV, 1896.

[d] Good examples of the effect of well-considered verbal descriptions in giving life to climatic data may be found in the second and third volumes of Hann's Handbuch der Klimatologie (2d ed.); also in Blanford's Climates and Weather of India, Ceylon, and Burma.

method of illustrating the cyclonic and anticyclonic control of weather elements, which was devised some years ago by Prof. W. M. Davis, the predecessor of the present writer as instructor in charge of the courses in meteorology and climatology in Harvard University, and which has since been somewhat extended and modified. The local (Boston) weather maps for a week are mounted separately on linen, fastened together at their left-hand margin, and also fastened onto a sheet of thick cardboard, but so arranged that the maps can be turned over like the leaves of a book. Below these maps, and on the same cardboard, there are pasted, first the thermograph curve for Boston, or some other New England station, for the week in question, and below the thermograph curve, but also on the same cardboard, the barograph curve for the same station and the same week. The state of the sky, observed at as frequent intervals as possible, is indicated by the words "clear," "fair," etc., written at the proper points along the thermograph curve, as may be also the times of beginning and ending, and the amounts of precipitation. Along the barograph curve, in a similar way, the wind direction and the wind velocity in miles per hour may be indicated at frequent intervals, and, if desired, the relative humidity may also be shown in percentages.[a]

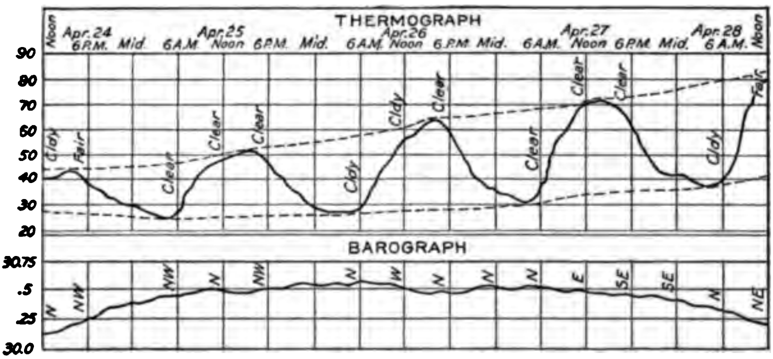
By a comparison of these curves (the data indicated being added to them as just suggested) with the weather maps, the cyclonic and anticyclonic variations of the different elements can easily be followed from day to day. These diagrams furnish the best means of illustrating weather types, and thus of emphasizing the cyclonic and anticyclonic units, which have come to the writer's attention. They offer abundant and varied exercises for discussion in "laboratory work," and give the student a more vivid idea of the complexity of such a climate as that of the extra tropical latitudes than he can obtain from any of the usual climatic tables. A fairly complete and satisfactory set of such diagrams illustrating New England weather types is already provided in the climatological laboratory of Harvard University, and these have proved so satisfactory that the writer is about to make up similar series from different parts of the United States as a preparation for a more complete, and as it seems to him a more rational, presentation of the climatology of the United States than has yet been attempted. It is of course obvious that a large number of thermograph and barograph curves must be collected and examined before the best normal and anomalous types can be selected, and the variation of the curves in different parts of a cyclone or anticyclone adds to the complexity of the problem. But a carefully selected set of type weather conditions, both normal and anomalous, illustrated in the way here suggested, by means of maps and curves, will be of the greatest help

[a] If desired, the curves from self-recording wind register, rain gauge, and hygrometer may be pasted on the cardboard below the barograph curve.

to any teacher or student of climatology. If a series of such curves could be published with each volume of tabulated climatological data it would be a very great help in giving a vivid idea of the climate in question.

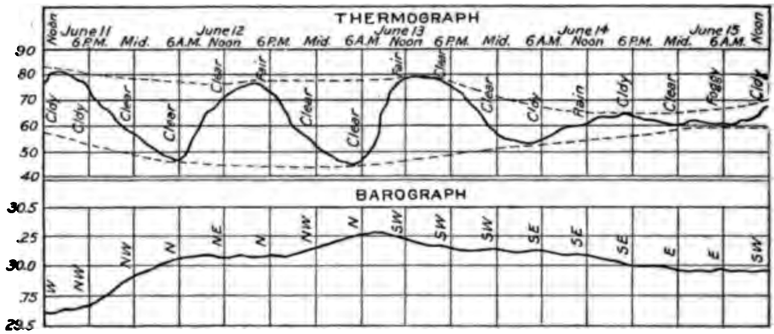
The illustrations which follow are taken from curves in the climatological laboratory of Harvard University, prepared some years ago under the direction of Professor Davis. As any such typical curves remain typical curves whenever they were recorded, the year of occurrence matters little. The writer hoped to present curves from the years 1903 and 1904, but was prevented by lack of time in the preparation of this paper, and by the fact that these curves were not available at the Boston office of the Weather Bureau.

The diagrams here given are taken from curves recorded at the office of the Jackson Company, Nashua, N. H., during 1888—one curve bears the date 1890. The times of beginning and ending and the amounts of rainfall, as well as the wind velocity and relative humidity, are not entered on these curves. The distance between the broken lines which join the crests and the troughs of the thermograph curves shows the amount of the diurnal range (or change) of temperature. The belt inclosed between these lines rises and falls with the cyclonic or anticyclonic control of the temperature. Although pressure is not an element of importance in climatology, it will be seen that the barograph curve, when employed in such diagrams as these, is a great help in showing the extent and duration of the successive cyclonic and anticyclonic controls.[a]



Normal diurnal curves, of large range, with a rise in the mean temperature and in the maxima and minima from day to day under the clear sky of a spring anticyclone. At the beginning of this spell (April 24) the cool wave in front of the approaching anticyclone brought lower temperatures, while the warming increased in the light winds near the center of the high. The rise in the mean temperature from April 25 to 27 is shown by the rise of the dotted temperature belt.

[a] In the Monthly Weather Review for February, 1904, pp. 78–79, W. E. Donaldson, observer of the Weather Bureau, published a few typical thermograph curves for Binghamton, N. Y., which, while much less complete than those here figured, are nevertheless selected from a similar point of view.



Somewhat similar conditions later in the season (June) with higher maxima and minima. On June 14 and 15 a marked narrowing of the dotted temperature belt, indicating very small temperature ranges with low maxima, under the rainy and cloudy conditions of these days. In both figs. 1 and 2 the temperature belt is widest under high pressure conditions.

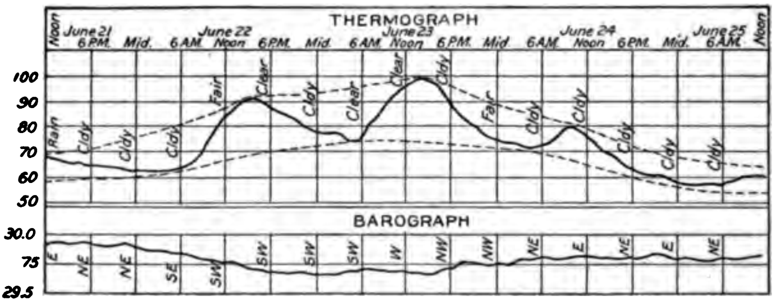
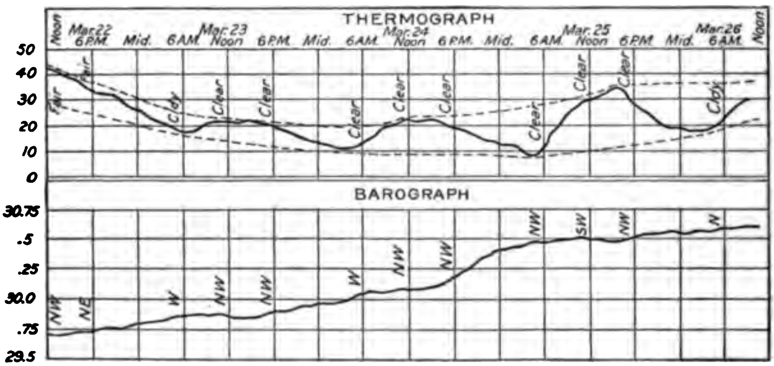
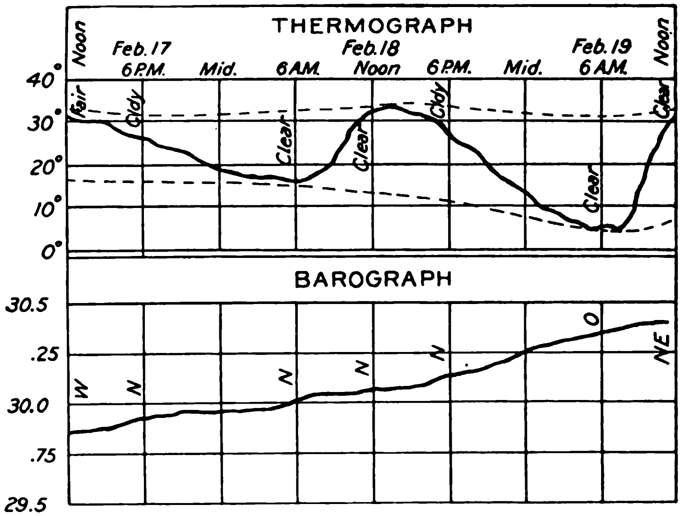


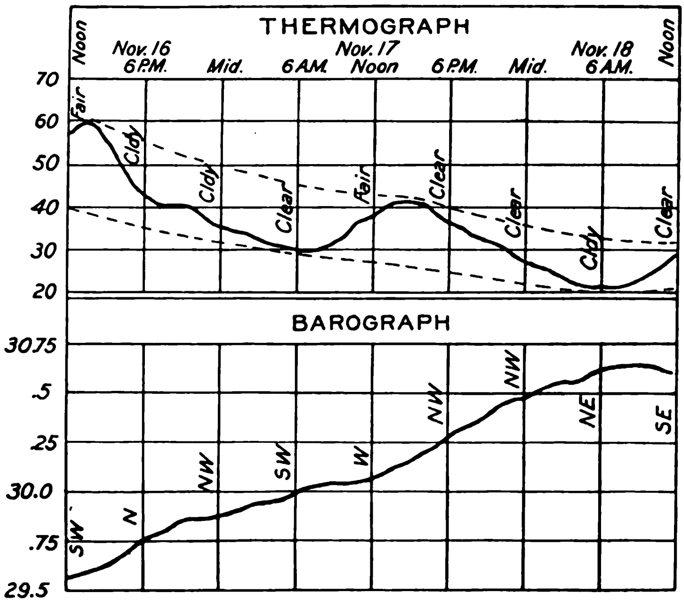
Diagram illustrating the contrast between southwesterly and northeasterly winds in New England in summer. Beginning with an even temperature under cloudy skies and rain, the incoming of southwesterly winds and fair or clear weather at once brings a marked diurnal range, with a rise in the temperature belt as a whole, under cyclonic control, to a high maximum (June 23). With a shift to northwest winds a general fall in temperature occurs, which is continued under the succeeding east and northeast winds, with small ranges under cloudless skies, the temperature belt as a whole falling to the right end of the diagram. The low noon maximum on June 25 is due to the cool northeast winds and clouds.



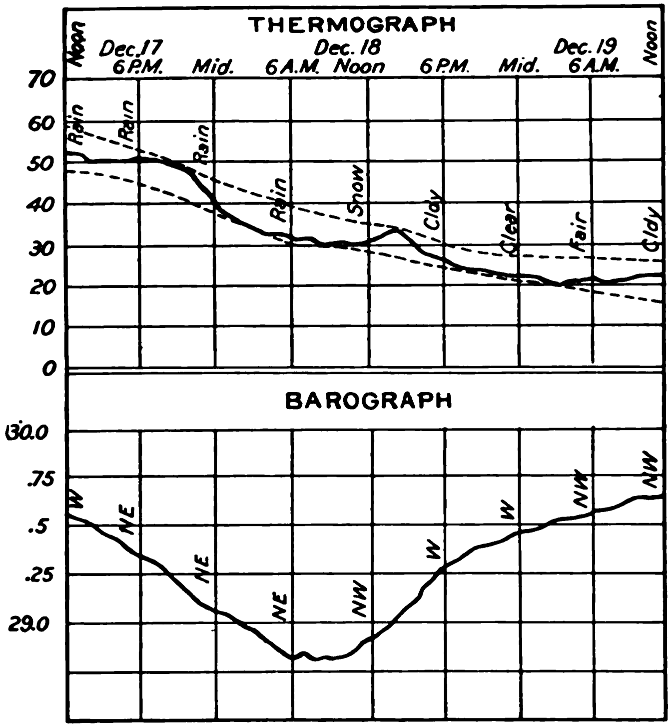
Under the active northwest winds in the rear of a March cyclone the temperature belt is narrow (small diurnal range), because the imported cold can not be overcome by the noon warming produced by the sun. With the approach of the center of the high, and with light variable winds, the diurnal range increases; the temperature belt therefore widens, and the axis of the belt as a whole rises.



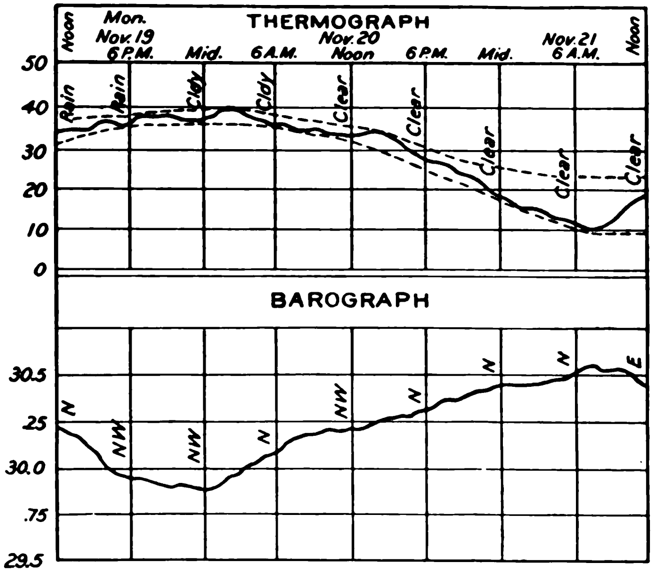
Under the light winds of a winter anticyclone we find a moderate winter noon temperature (February 18), the result of a fairly well-marked diurnal range (for winter) and a cold night, under clear skies and with no wind. Notice the widening of the temperature belt toward the center of the anticyclone.



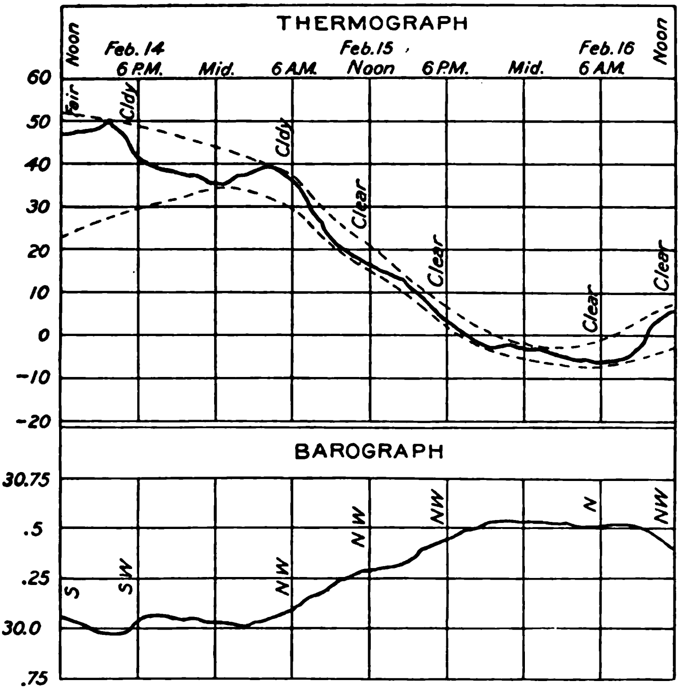
An autumn cold wave in front of an approaching anticyclone carries the whole temperature belt down, but is unable wholly to extinguish the diurnal range. The minimum temperature occurs under the maximum pressure, i. e., is the result of local nocturnal radiation.



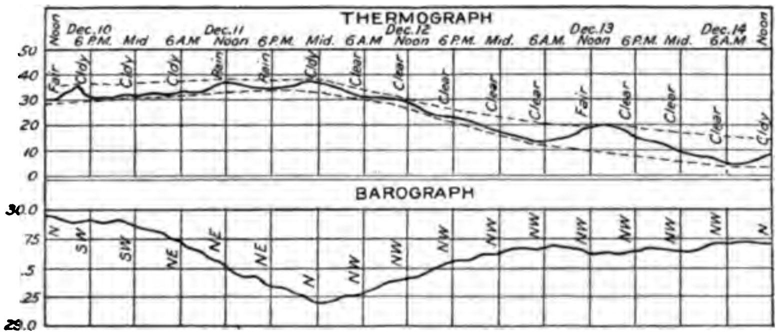
A marked fall in temperature under the cool northeast winds before the passage of a winter anticyclone, with an almost steady fall through noon (December 18) as the result of the imported cold in the westerly winds on the rear of the cyclone. On December 18 the maximum temperature came at the first midnight and the minimum at the second midnight.



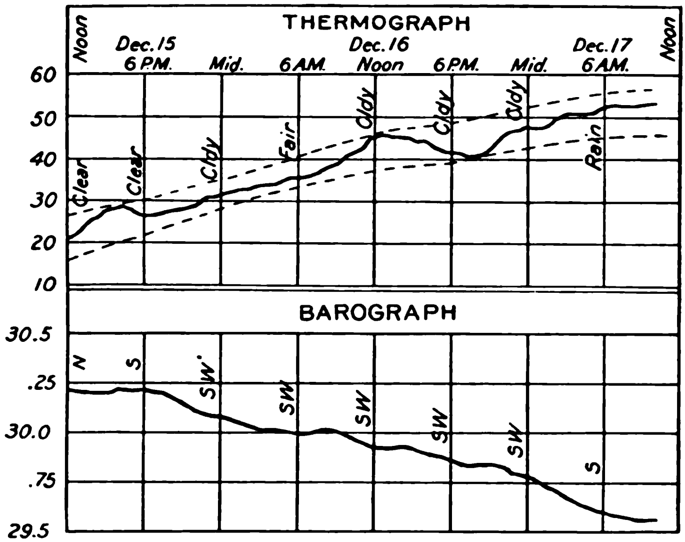
November cold spell. After a maximum temperature at *night* (November 19-20), a fall in temperature, beginning shortly after midnight, continues over noon (November 20) and until early in the morning of the following day. The temperature belt is very narrow, showing slight ranges of temperature under the rain and cloudy sky of November 19, and widens under the clear skies and light winds of the anticyclone (November 21). The minimum temperature (November 21) comes under the clear sky of the anticyclonic night.



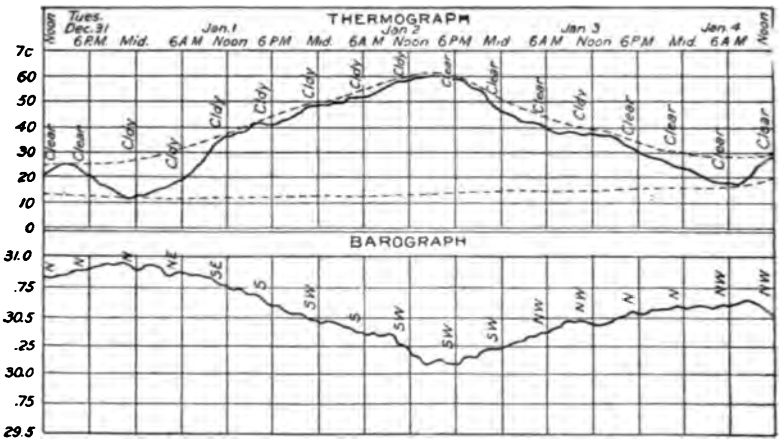
Somewhat similar to preceding. A maximum of 50° is reached under the warm southerly winds of a passing winter cyclone. With a shift of wind into the northwest, a rapid fall of temperature takes place, from the early morning of one day (February 15) through noon, with hardly any trace of diurnal warming, although the sky is clear, to the early morning of the next day, the minimum coming with the highest pressure, and on a clear night. The cyclonic range of temperature is here very clearly brought out in the drop of the temperature belt from one side to the other of the diagram.



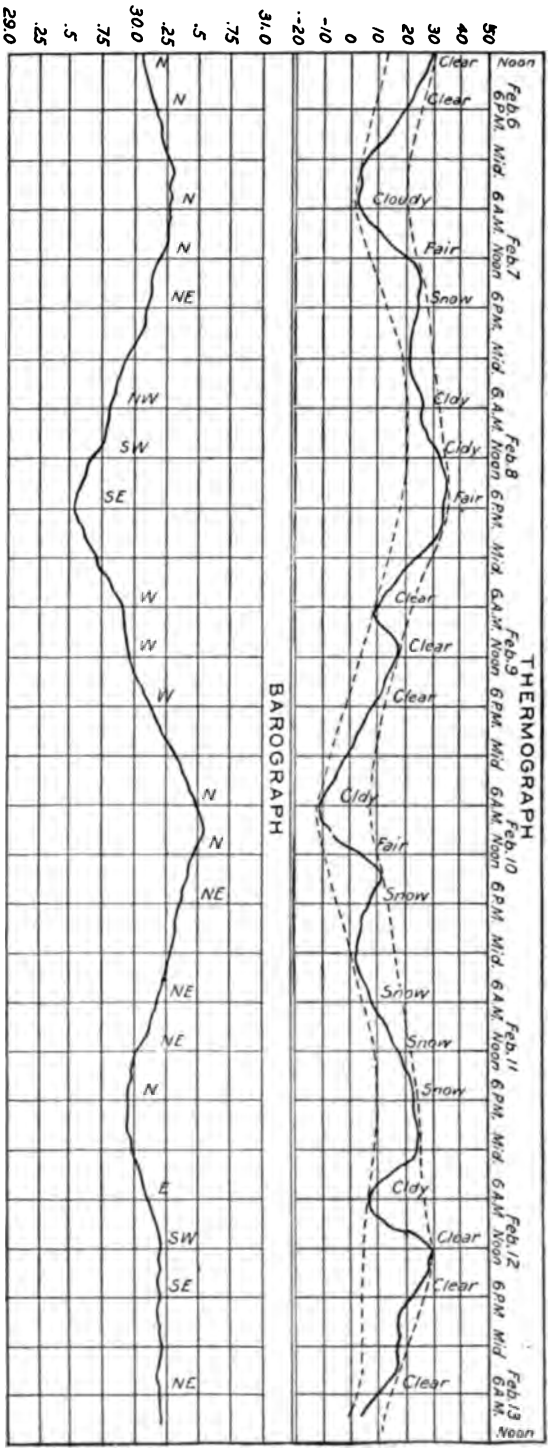
In this curve we have only a moderate cyclonic range of temperature, because the center passed to the south of the station, and thus the warm southerly winds (noted in figs. 11 and 12) were lacking. The cyclonic clouds and rain resulted, as usual, in practically extinguishing the diurnal range, the maximum temperature comes with the minimum pressure, as is usually the case in winter; the cold wave on the rear of the cyclone carries the temperature belt down (as in fig. 9), the downward slope being but slightly interrupted by a weak diurnal maximum in the afternoon of December 13.



An excellent illustration of the cyclonic control of winter temperature changes. With the approach of a winter cyclone warm southwesterly winds ("sirocco") cause a decided rise of temperature, which is entirely independent of the time of day. The maximum on December 15 comes at midnight; the rise of the temperature belt continues over night of the 15th, through the 16th, and into the morning of the 17th. A slight cooling appears in the early night of the 16th, but the belt as a whole is very narrow. Notice particularly the fact that on December 16 the minimum temperature comes at the first midnight and the maximum at the second midnight, i.e., the "diurnal range" is cyclonically controlled.



A good example of the typical winter temperature controls. A marked maximum of about 60° under the control of the warm southwest winds in association with a winter cyclone, with cloudy weather, comes at the time of lowest pressure. The two maxima come at the crests of the two high-pressure areas. On January 1 the minimum is at the initial midnight, the maximum is at the final midnight, the "diurnal range" is wholly cyclonic. On January 3 the maximum is at the initial midnight and the minimum at the final midnight, the opposite condition, but again the range is cyclonic. The temperature belt rises and falls as the cyclone or anticyclone may determine. A glance at the thermograph curve on January 1 and 2 shows how completely the diurnal control has disappeared.



Thermograph and barograph curves for a whole week, illustrating the strong ranges of pressure and of temperature which are characteristic of winter weather. The rise and fall of the dotted temperature belt shows the cyclonic temperature range and corresponds inversely with the pressure changes, i. e., with high pressure (as on February 6 and 10) we find the minimum temperatures in the early morning, and with low pressure (as on February 8) we find the maximum temperatures.

THE CANADIAN CLIMATE

By R. F. STUPART, Toronto, Canada.

That portion of the American continent which lies north of the international boundary is so vast in extent and so varied in its geographical features that it is not surprising to find the climatic conditions in Canada most varied and interesting. The most southern point of Canada is on nearly the same parallel as Rome, Italy. The northern boundary of the Dominion is the Arctic Ocean.

Canada is the northern half of a continent which stretches from the subtropics to the Arctic Sea. The older provinces of the Dominion, viz, Ontario, Quebec, and the maritime provinces, lie wholly farther south than does any portion of Great Britain. Toronto is 550 miles farther south than London, Montreal 418 miles farther south, and Halifax 478 miles farther south. Many may be surprised to learn that a large part of Ontario lies as far south as the south of France and northern Spain and Italy, and that the southern point of Ontario is farther south than Rome. A portion of the Northwest Territories, a strip 70 miles in width, including parts of Manitoba, Assiniboia, and Alberta, are also farther south than any portion of England. No part of Canada's present wheat fields in Manitoba and the Northwest Territories lies as far north as Scotland, but it is the writer's belief that in the not distant future some of the choicest grazing land of America will be found under the shelter of the Rocky Mountains in the basin of the great Mackenzie River, in an area extending from a latitude corresponding to that of the Scottish border northward nearly to the Arctic Circle.

Vancouver Island, in the Pacific Ocean, occupies somewhat the same position in relation to the American continent that Great Britain, in the Atlantic, does to Europe, lying between nearly the same parallels of latitude. The climate, as in all other parts of British Columbia, varies much with the orographical features of the country. The annual rainfall along the exposed western coast of the island is very great, generally exceeding 100 inches, but in the more eastern districts it is less than half that amount. A comparatively dry period

extends from May to September, while copious rains fall between September and March. The mean monthly and mean annual temperatures correspond very closely with those found in parts of England—the summers are quite as long, and severe frosts scarcely ever occur.

On what is usually termed the lower mainland of British Columbia, which includes all parts of the province that lie at comparatively low levels, with no mountains to the west, the climate is everywhere equable and mild; but it is only in the valley of Fraser River that any extended series of meteorological observations have been made. The lower Fraser Valley, in its northward stretch to its junction with the Thomson River, traverses latitudes corresponding with the southern half of England. The spring opens early, the summers are warm, and the winters, which are usually mild and rainy near the coast, increase somewhat in severity with increasing distance from the sea. At Agassiz, about 70 miles from Vancouver, is situated one of the Dominion experimental farms; the average mean temperature for January at this place is 33° and for July 64°, with a mean daily range of 10° in the former month and of 26° in the latter; the lowest temperature on record is −13° and the highest 97°. Frosts seldom occur as late as May and there is no record of any during the summer months. The annual rainfall is 67 inches, two-thirds of which falls between the beginning of October and the end of March. At New Westminster the rainfall is essentially the same as at Agassiz, the winter mean temperature being a few degrees higher, and the summer temperature a little lower.

The change in climate between the west and east sides of the Coast Range is decidedly abrupt. The Pacific winds are deprived of much of their moisture in ascending the western slopes of the mountains, and the air flows eastward or is drawn down to lower levels, becoming drier and warmer; hence the interior plateaus between the Coast and Selkirk ranges possess a relatively dry climate; the summers are warmer and the winters colder than on the lower mainland. The cold of winter is, however, scarcely ever severe, and the hottest days of summer are rendered pleasant by the fact that the air is dry and the nights are cool. In all the lower levels of British Columbia March is distinctly a spring month. In the more southern divisions the mean temperature of April corresponds very closely with that of the same month in England, while the summer may very well be compared with that of southern Ontario, except that the air is much drier and the rainfall is scant. Over the larger portion of Yale district apples, pears, plums, cherries, as well as cereals, are most successful crops, and in Okanogan, grapes and peaches thrive and tobacco is yearly proving more successful. The meteorological tables for Kamloops, Vernon, and Mission valleys show approximately the mean temperature and rainfall values of the region. In the more mountainous region of East Kootenai the

winters are colder again, but even here the summers are warmer and the winters not so cold as in St. Petersburg.

On the main line of the Canadian Pacific Railway, about 100 miles east of Kamloops, among the foothills of the Selkirks, is Griffin Lake, and here the effect of distance from the high coast range and also of increased altitude is shown in a larger amount of precipitation and a somewhat lower temperature. The snowfall aggregates 130 inches each winter.

As the Selkirks are ascended the effect of increasing altitude becomes manifest, and at the Glacier House, at the base of Mount Sir Donald, the mean monthly temperature averages nearly 8° lower than at Griffin Lake. The precipitation also is much greater, owing chiefly to an exceptionally heavy snowfall between October and April, the fall aggregating as much as 36 feet. July and August are months with a mean temperature rarely exceeding 57° or 58°, and with pleasantly warm days and usually bright sunshine, followed by cool nights, the marvelous scenery of the Selkirks and the great Illacilewaet Glacier can be thoroughly enjoyed.

East of Rogers Pass, in the valley of the northward-flowing Columbia, again is found the chinook effect, as is shown by drier weather and a greater preponderance of clear skies than on the western slopes. The level is still high, however; the lofty Rockies lie not far eastward, and the distance from the coast is now so great that except when the chinook is blowing the character of the winter partakes rather of the continental than the coastal type. Reference to the tables will show that at Donald nearly all months are characterized by a large daily range of temperature, and that occasionally in winter very low temperatures are recorded.

A knowledge of the climate of Manitoba and the Northwest Territories is of considerable importance at the present time, as thousands of immigrants are pouring into the country. The available meteorological observations at most stations in the Canadian Northwest extend over a period of twenty years. We can therefore at least form a fair estimate of the climatic changes. At Winnipeg the series of observations extends to thirty years, and by comparing the records from one part of the country with those of another we are aided much in our estimate.

On considering the spring and summer seasons, which are the more important from an agricultural standpoint, it will be found by reference to the accompanying tables that spring usually opens a little earlier in Alberta, near the mountains, and in southwestern Assiniboia than it does farther east in Assiniboia and in Manitoba, but that after early in May the more eastern districts become the warmer, and that the average temperature of the three summer months in Manitoba, taking Winnipeg as approximately indicating the climate of the Prov-

ince, is some 5° higher than during the same season at Calgary and Edmonton. An average daily maximum temperature in April of 53° at Calgary, 52° at Edmonton, 58° at Medicine Hat, and 47° at Winnipeg show that April is truly a spring month, and verifies the oft-repeated statement that spring seeding is well under way, or perhaps completed, in that month.

The rapid upward trend of the temperature curve continues during May and June, and from the middle of May until the end of July the heaviest rainfall occurs throughout the whole region under discussion—a rainfall which is nearly the same as that of Ontario and Quebec during the same period, and which, as a rule, is ample to insure successful crops. Bright, hot days may be confidently looked for during July and August, and very occasionally in these months temperatures exceeding 90°, perhaps nearly 100°, are recorded; but the average mean maximum in July of 78° at Winnipeg, 76° at Qu'Appelle, 82° at Medicine Hat, and 75° at Calgary indicate a not unpleasant warmth, while the corresponding minima show that the nights are pleasantly cool. A fact of peculiar interest in connection with the climate of our Northwest Territories is that the summer season in Athabasca and the basin of the great Mackenzie River is nearly as warm as in Alberta. At Edmonton and Calgary the mean summer temperature is 59°, Dunvegan is 58°; Fort Chippewyan, 59°; Fort Simpson, 57°. The explanation of this lies chiefly in the fact that the insolation—i. e., heat received from the sun—scarcely varies about midsummer between the parallels of latitude 40° and 60°, the larger number of hours the sun is above the horizon in the higher latitudes very nearly balancing the effect of less direct solar radiation, and as after early May the snow has all disappeared we find the isothermal lines running nearly parallel with the Rocky Mountains. In the writer's opinion, this far northwestern portion of the Dominion, the Mackenzie River district, is a land of great promise, but it should be spied out and experiments in agriculture made before any extensive immigration is encouraged, and this for the reason that, while the summers are warm, a rapid downward trend of the temperature curve is very noticeable after the middle of August, and frost is not uncommon before the close of that month. While, as we have seen, the summer climate as regards temperature in the Mackenzie River basin and Alberta does not differ very greatly from that found in Manitoba, this can not be said of the colder seasons. Southern Alberta has a much milder winter than any other portion of the territories, and the cold becomes greater to the eastward, over Assiniboia and Manitoba, and also northward, toward Athabasca and the Mackenzie basin. Eastwardly from Alberta the average winter temperatures—December–March—are as follows: Calgary, 17.1°; Medicine Hat, 16.4°; Qu'Appelle, 5°; Winnipeg, 1.7°. Farther north the change is even more rapid, and is in strong contrast

to the small variation during the summer: Calgary, 17°; Edmonton, 13° above zero; Dunvegan, 1°; Fort Chippewyan, 5° below; Hay River, at the entrance of Slave Lake, 9° below; Fort Simpson, in latitude 62°, 13° below; and Fort Good Hope, near the Arctic Circle, 25° below. Since the winters are so cold in the far northern territories, while the summers are warm, the time of the opening of spring becomes all important, and the average date can not be placed much before quite the end of April in the Peace River Valley and early May farther north in the Mackenzie basin. All through April, however, the snow is melting fast and the temperature is frequently above 50°. Wild fowl are flying during the latter half of the month. Other features of peculiar interest in connection with the climate of the territories near the mountains are the rapid changes of temperature, which in winter frequently occur in short intervals of time, the marked variableness of the mean winter temperature in different years, and the variableness of rainfall during the summers of different years. The rapid changes in short intervals are accounted for by the well-known chinook or Föhn effect, which is observed to a greater extent under the lee of mountains on the windward side of which moisture is precipitated. We know that the moist ocean winds which are forced up the western slopes of the mountain do not cool as rapidly as they otherwise would, owing to the condensation of their moisture, and that subsequently mechanical heating by compression as they descend the western slopes brings them to the prairie comparatively warm and dry. It is when a cyclonic area from the Pacific moving across northern Alberta causes a rapid southwesterly and westerly flow of air across the Rocky Mountains that the chinook blows over our western prairies. Sometimes a change of wind from north and northeast to southwest will in Alberta mean a rise of temperature from perhaps 20° below zero to 40° above in a few hours.

The variableness of seasons is certainly to a great extent due to the varying position of the mean track of storm centers in different years. The average mean track for January, deduced from many years' observation is across British Columbia, but in some winters the centers persistently move farther south than in others, and pass into the continent over Washington or Oregon States, and then the chinook does not blow east of the mountains in the Canadian territories, and northeast and north winds prevail, accompanied by continued low temperatures. In other years the storm centers just as persistently move across northern British Columbia, and then the chinook is the rule rather than the exception and the weather under the lee of the mountain keeps mild. As an example of the variableness of seasons, the mean temperature of January, 1886, at Edmonton was 13.4° below zero, while in 1889 it was 21.9° above, a range of 35.3°. In February, 1887, it was 10.4° below and in 1889 21.9° above,

a range of 32.3°. In November, 1896, it was zero, and in November, 1890, it was 38°.

It will be obvious that as the mean track of low areas is over Vancouver Island, the farther we depart northward from this latitude the less frequent will be the chinook, and hence the departures from normal values are likely to be less marked as the latitude increases, and this is found to be the case.

A feature of very pronounced importance in connection with the precipitation—i. e., rain and melted snow—of Manitoba and the larger portion of the territories, is that in the former Province 50 per cent and farther west more than 62 per cent of total for the year falls between May and August, and June is the month of heaviest rainfall—just the very period when moisture is required by the growing crops.

From information derived from a variety of sources, the writer has formed the opinion that 8 inches of well-distributed rainfall between May and August in our territories at present inhabited is sufficient for agriculture, and that farther north, where the ground is more deeply and permanently frozen, less will probably suffice.

In Manitoba the rainfall is greater than in any portion of the Northwest Territories. The normal annual precipitation over the Province is approximately 22 inches, and the May to August rainfall is 11.5 inches; drought is therefore not much to be feared here, but westward the danger increases. From Regina westward to Medicine Hat and northward to Saskatoon there are very few rainfall records that extend over a few years, but there is fair evidence that the average annual precipitation in this area nowhere exceeds 15 inches, and at many points is less than that amount. By reference to the table it will be seen that the records of eighteen years indicate an average rainfall of 11 inches in Saskatchewan and 12 inches in Alberta, which, with a snowfall of about 55 inches, gives a total annual precipitation of 16 or 17 inches over the larger part of Saskatchewan and 17 or 18 inches in Alberta. But it is to be remembered that the seasonal precipitation in the far West is extremely variable. At Calgary in 1892 the total precipitation of the year was but 7.91 inches, while last year it was 34 inches. For five years the rainfall has been ample in this region, but for many years prior to 1897 it was scant, and in several of the years irrigation appeared necessary for successful crops. We may fairly assume that there will be a return to the dry conditions, and that the government is acting in a most judicious manner in providing for irrigation in parts of Alberta.

The writer is of the opinion that the chinook has played an important rôle in producing a treeless prairie land in southern Alberta and Assiniboia, and that the presence of wooded lands in northern Alberta and farther north is largely due to the diminishing frequency of the

... as a rule, not quite so warm as in ... seldom experienced, except very ... stations of New Brunswick. The average ... is between 40 and 45 inches except ... of Nova Scotia, where it is nearly 10

... Annapolis Valley in Nova Scotia in October will ... nothing can be conceived more beautiful ... tints which everywhere enhance the loveliness, whether in the land of Evangeline or in the ... fresh water seas which lave Ontario's shores, the ... admit that in truth the most salient feature ... is not the cold of winter, but the perfection of autumn.

... Canada, except the region near the coast in British ... with more sunshine than any portion of Great ... Holland, or northern France. Nearly all parts of ... have an annual percentage of over 40, and a summer ... between 53 and 59, whereas it is only in the more ... England that a normal annual percentage of 36 is ... summer figures, while in a few instances up to 50, ... generally between 35 and 45. At German stations the ... maximum averages under 50 per cent, and in a few cases ... In the south of Europe much higher values are obtained: ... Zurich, 57; Trieste, 66; Lugano, 67; Rome, 75; Madrid, ... These figures show that it is only the southern parts of Europe ... have more sunshine than Canada.

A few facts regarding the climate of the "golden" Klondike may perhaps be acceptable to some persons. Its geographical position is as follows: Yukon Territory has nearly the shape of a right-angled triangle, of which the base is an arc of the 60th parallel, the perpendicular an arc of the 141st meridian, and the hypotenuse the Rocky Mountains. To reach the Klondike the traveler now lands at Skagway, on the Pacific coast, crosses the Coast Range of mountains by railway, passing through superb scenery, and then has a trip of 340 miles by steamer down the Yukon River. The distance from Toronto to Dawson city is 2,700 miles as the crow flies.

A somewhat broken series of observations at Dawson and various other places in Yukon Territory between 1895 and 1898, and a continuous series at Dawson during the past five years, afford data for estimating with a fair degree of accuracy the average climatic conditions of the Klondike. The average annual mean temperature is about 22°; the mean of the three summer months is about 57°, July being 61°, and of the three winter months 16°, with January 23°. Spring may

snowfall will mean low water in the spring freshets, which is disastrous, as the logs may not be floated to the great watercourses and the mills. The Ontario lumberman, the farmer, and the business man all pray for a winter with lots of snow and steady cold; these are conditions which mean prosperity, and when the snow begins to melt in March all may look forward with confidence to a short spring followed by a long and delightful summer, which fades gradually into autumn, with its golden tints, which last to the middle of October, and not infrequently into November. The climate of southern Ontario is very appreciably warmer than that of the more northern parts of the Province; were the month of March a little warmer it would be well nigh a perfect climate. Signs of spring begin to multiply early in April, or indeed in March, and between the middle of May and the middle of September the whole district is included between the same isotherms as the greater portion of France, and it is only after a protracted autumn that winter sets in, about the beginning of December. The winters are by no means severe and the summers seldom oppressively hot, this being due to the tempering influence of the Great Lakes, by which this portion of Ontario is surrounded. In the more southern and western counties of the Province the April mean temperature corresponds nearly to that of the whole south of Scotland, and in May the mean temperature of the whole district is slightly higher than for the south of England. The summer months proper are distinctly warmer than in England, but in few districts does the mean temperature exceed 70°, hence the heat is by no means excessive. The annual precipitation of the whole of Ontario lies between 30 and 40 inches, which is fairly evenly distributed throughout the year; in summer, however, the rain generally falls in thunderstorms, and cloudy, wet days are of very rare occurrence.

The summers in western Quebec are as warm as in western Ontario; in July the 70° isotherm passes not far south of Montreal, the 65° line passes through Quebec city, and most of the Gaspe Peninsula has a mean temperature somewhat below 60°. The winters are cold, but dry and bracing, and may very fairly be compared with those of St. Petersburg and Moscow. Zero temperatures, while not infrequent, are not the rule, and it is only on a few occasions in each winter that exceedingly cold dips are experienced. The third week in April sees the trees along the St. Lawrence budding, and it is not until late in November that the last red sear leaves fall.

The opening of spring in the maritime provinces is usually a little later than in southern and western Ontario and the Northwest Territories, and somewhat earlier than in the lower St. Lawrence Valley, on the other hand, the summer lingers longer, especially in the Annap-

TABLE I.—*The average mean highest, mean lowest, and mean temperature; the highest and lowest temperature and mean daily range; also percentage of cloud and precipitation in inches at various stations in Canada.*

VICTORIA, B. C.: 16 YEARS.

[Latitude 48° 24′, longitude 123° 19′, height 85 feet.]

	Mean—				Absolute—		Per cent of cloud.	Precipitation.
	Highest.	Lowest.	Temperature.	Daily range.	Highest.	Lowest.		
	°	°	°	°	°	°		*Inches.*
January	41.9	33.1	37.5	8.8	56	−1	78	5.28
February	44.1	34.1	39.1	10.0	60	6	75	4.03
March	48.9	36.1	42.5	12.8	68	17	67	2.92
April	54.9	39.4	47.2	15.5	75	29	65	2.42
May	61.6	44.2	52.9	17.4	83	31	61	1.44
June	65.5	47.8	56.6	17.7	86	36	60	1.20
July	70.9	49.6	60.3	21.3	90	37	42	.40
August	69.2	49.8	59.5	19.4	88	37	42	.60
September	63.8	46.1	55.0	17.7	85	30	53	2.16
October	55.8	43.7	49.7	12.1	70	22	67	2.37
November	48.3	38.8	43.6	9.5	63	17	79	6.97
December	45.5	37.0	41.3	8.5	59	8	79	7.98
Year	70.9	33.1	48.8	....	90	−1	64	37.77

NEW WESTMINSTER, B. C.: 10 YEARS.

[Latitude 49° 13′, longitude 122° 54′, height 330 feet.]

January	41.2	32.2	36.7	9.0	56	2	72	7.63
February	45.0	33.4	39.2	11.6	58	10	69	7.41
March	49.7	34 8	42.3	14.9	72	13	68	6.45
April	56.9	39.6	48.3	17.3	79	25	58	3.40
May	66.8	42.5	54.6	24.3	88	32	66	3.67
June	70.5	49.3	59.9	21.2	92	37	58	2.65
July	73.8	52.0	62.9	21.8	94	41	47	1.69
August	73.2	53.4	63.3	19.8	90	39	44	2.15
September	66.1	47.2	56.7	18.9	85	34	51	3.05
October	57.7	44.0	50.9	13.7	73	30	59	5.90
November	46.3	36.6	41.4	9.7	62	5	73	8.73
December	42.5	32.4	38.4	8.1	58	18	71	9.04
Year	....	....	....	....	94	2	61	61.77

KAMLOOPS, B. C.

[Latitude 50° 41′, longitude 120° 29′, height 1,193 feet.

January	30.7	17.7	24.2	13.0	56	−27	69	0.86
February	33.7	18.5	26.1	15.2	64	−27	69	.79
March	46.9	27.6	37.2	19.3	69	−5	51	.51
April	60.5	37.6	49.0	22.9	78	25	56	.37
May	70.2	45.9	58.0	24.3	100	26	58	1.11
June	75.6	51.3	63.5	24.3	101	39	56	1.42
July	81.8	54.8	68.3	27.0	101	44	48	1.61
August	82.1	54.9	68.5	27.2	101	39	50	1.09
September	69.5	46.1	57.8	23.4	87	31	46	.85
October	56.8	39.1	48.0	17.7	82	16	58	.61
November	40.0	28.3	34.2	11.7	65	−22	65	1.46
December	35.3	21.9	30.1	10.4	56	−16	70	.78
Year	82.1	17.7	47.1	....	101	−27	58	11.46

TABLE I.—*The average mean height, mean lowest, and mean temperature; the highest and lowest temperature and mean daily range; also percentage of cloud and precipitation in inches at various stations in Canada*—**Continued.**

AGASSIZ, B. C.

[Latitude 49° 14′, longitude 121° 31′; height 52 feet.]

	Mean—				Absolute—		Per cent of cloud.	Precipitation.
	Highest.	Lowest.	Temperature.	Daily range.	Highest.	Lowest.		
	°	°	°	°	°	°		Inches.
January	37.9	28.2	33.0	9.7	57	−13	62	7.29
February	63.5	31.7	37.6	11.8	64	−12	62	6.68
March	52.0	35.9	44.0	16.1	74	16	56	5.47
April	55.2	38.3	46.7	16.9	82	28	60	5.49
May	62.9	44.8	53.9	18.1	90	30	55	4.85
June	69.5	48.3	58.9	21.2	95	36	52	3.97
July	76.7	51.0	63.9	25.7	95	38	35	1.55
August	79.0	50.5	64.7	28.5	97	38	30	1.62
September	67.4	46.7	57.0	20.7	90	32	43	5.25
October	61.3	42.1	51.7	19.2	82	29	55	6.56
November	44.4	34.1	39.3	10.3	73	9	67	8.69
December	40.8	31.9	36.3	8.9	58	8	67	9.43
Year	57.5	40.3	48.9	17.2	97	−13	54	66.85

MISSION VALLEY, B. C.

[Latitude 49° 51′, longitude 119° 33′; height 1,200 feet.]

January	28.9	14.7	21.8	14.2	46	−10	....	1.83
February	36.6	19.8	28.2	16.8	55	−15	....	1.06
March	45.8	23.9	34.8	21.9	65	− 6	....	.23
April	58.1	31.9	45.0	26.2	79	14	....	.64
May	64.9	39.6	52.2	25.3	86	25	....	1.57
June	74.0	42.9	58.4	31.1	94	29	....	.89
July	81.2	46.8	64.0	34.4	98	32	....	.38
August	80.3	44.8	62.5	35.5	95	31	....	.23
September	63.9	37.5	50.7	26.4	82	20	....	1.51
October	54.9	30.4	42.7	24.5	74	16	....	.70
November	37.5	23.3	30.4	12.2	56	−17	....	1.90
December	33.1	21.6	27.3	11.5	47	−12	....	1.85
Year	54.9	31.4	43.2	23.3	98	−17	....	12.28

SALMON ARM, B. C.

[Latitude 50° 42′, longitude 119° 18′; height 1,152 feet.]

January	28.6	13.1	20.9	15.5	50	−11	....	2.53
February	36.9	18.6	27.7	18.3	58	−20	....	1.28
March	46.1	24.1	35.1	22.0	60	− 1	....	.52
April	57.7	33.5	45.6	24.2	76	23	....	1.34
May	64.2	40.0	52.1	24.2	89	28	....	1.48
June	72.5	44.4	58.4	28.1	91	27	....	1.67
July	80.3	47.5	63.9	32.8	91	37	....	.67
August	78.7	45.9	62.3	32.8	94	34	....	.43
September	62.2	37.9	50.1	24.3	84	35	....	1.62
October	53.1	33.0	43.1	20.1	71	21	....	1.65
November	36.7	23.3	30.0	13.4	63	−21	....	2.13
December	34.9	24.0	29.4	10.9	62	− 2	....	2.10
Year	54.3	32.1	43.2	22.2	94	−21	....	17.40

TABLE I.—*The average mean highest, mean lowest, and mean temperature; the highest and lowest temperature and mean daily range; also percentage of cloud and precipitation in inches at various stations in Canada*—Continued.

CALGARY, NW. T.

[Latitude 50° 2′, longitude 114° 2′ W; height, 3,389 feet.]

	Mean—				Absolute.		Per cent of cloud.	Precipitation.
	Highest.	Lowest.	Temperature.	Daily range.	Highest.	Lowest.		
	°	°	°	°	°	°		*Inches.*
January	21.9	....	11.0	21.9	56	−41	41	0.52
February	24.3	1.8	13.0	22.5	59	−49	48	.66
March	35.9	12.4	24.2	23.5	75	−34	48	.75
April	52.6	26.7	39.6	25.9	77	−14	51	.67
May	63.6	35.7	49.7	27.9	90	12	53	1.78
June	68.9	42.4	55.6	26.5	94	36	49	2.45
July	74.9	46.5	60.7	28.4	96	31	43	2.68
August	73.7	44.9	59.3	28.8	95	30	37	2.14
September	63.7	36.8	50.3	26.9	89	17	44	1.36
October	54.9	28.1	41.5	26.8	85	8	41	.48
November	35.9	13.9	24.9	22.0	70	−31	42	.88
December	30.1	10.8	20.5	19.3	56	−39	47	.59
Year	74.9	....	37.5	....	95	−49	45	14.96

WINNIPEG.

[Latitude 49° 53′, longitude 97° 7′; height, 760 feet.]

January	5.4	−16.2	5.4	21.6	40	−48	52	0.86
February	10.4	−12.6	− 1.1	23.0	46	−46	50	.97
March	24.6	.5	12.5	24.1	62	−38	48	1.00
April	46.6	25.3	36.0	21.3	90	−14	50	1.59
May	65.1	39.0	52.0	26.1	95	15	51	2.21
June	74.5	49.7	62.1	24.8	96	21	49	3.29
July	78.3	53.8	66.0	24.5	96	36	45	3.08
August	75.9	50.5	63.2	24.4	98	30	45	2.67
September	64.7	41.0	52.9	23.7	94	19	53	2.03
October	50.2	29.3	39.7	20.9	86	− 3	63	1.70
November	27.8	10.0	18.9	17.8	64	−34	63	1.08
December	14.6	− 5.3	4.6	19.9	45	−53	57	.91
Year	78.3	−16.2	33.5	....	98	−53	52	21.39

TORONTO.

[Latitude 43° 40′, longitude 79° 24′; height, 350 feet.]

January	28.9	14.9	21.9	14.0	58	−26	74	2.90
February	29.6	14.5	22.0	15.1	54	−25	69	2.58
March	35.6	21.4	28.5	14.2	70	−16	63	2.67
April	48.9	32.8	40.8	16.1	90	6	58	2.42
May	61.3	42.9	52.1	18.4	93	25	57	3.06
June	72.0	52.7	62.4	19.3	93	28	52	2.88
July	77.4	57.9	67.6	19.5	98	39	50	2.99
August	75.6	57.0	66.3	18.6	99	40	50	2.87
September	67.5	49.9	58.7	17.6	94	28	50	3.27
October	54.1	38.7	46.4	15.4	81	16	62	2.46
November	42.0	29.9	36.0	12.1	67	− 5	75	3.09
December	32.2	19.6	25.9	12.6	61	−21	76	2.92
Year	77.4	14.5	44.1	....	99	−26	61	34.11

TABLE I.—*The average mean highest, mean lowest, and mean temperature; the highest and lowest temperature and mean daily range; also percentage of cloud and precipitation in inches at various stations in Canada*—Continued.

MONTREAL.

[Latitude 45° 30′, longitude 73° 35′; height, 187 feet.]

	Mean—				Absolute.		Per cent of cloud.	Precipitation.
	Highest.	Lowest.	Temperature.	Daily range.	Highest.	Lowest.		
	°	°	°	°	°	°		*Inches.*
January	20.7	4.4	12.5	16.3	52	−26	61	3.73
February	23.4	7.4	15.4	16.0	50	−24	59	3.07
March	30.7	16.9	23.8	13.8	57	−15	56	3.79
April	49.0	32.8	40.9	16.2	77	8	53	2.24
May	64.0	45.8	54.9	18.2	92	25	58	2.95
June	73.7	56.4	65.0	17.3	98	38	53	3.53
July	77.4	60.8	69.1	16.6	94	46	52	4.29
August	75.1	58.9	67.0	16.2	90	45	53	3.57
September	66.5	50.8	58.6	15.7	91	33	49	3.30
October	52.9	39.0	46.0	13.9	78	22	59	3.13
November	38.7	26.6	32.7	12.1	68	− 1	72	3.74
December	26.2	12.1	19.2	14.1	59	-21	66	3.65
Year	77.4	4.4	42.1	....	98	-26	58	40.99

FREDERICTON.

[Latitude 45° 57′, longitude 66° 36′; height, 164 feet.]

January	23.3	2.8	13.0	20.5	52	−34	52	2.48
February	26.3	3.9	15.1	22.4	51	−30	55	3.76
March	35.2	16.0	25.6	19.2	65	−27	52	4.12
April	48.9	28.1	38.5	20.8	77	− 4	53	2.59
May	63.2	39.9	51.6	23.8	92	24	58	4.28
June	72.2	49.1	60.6	23.1	97	32	55	3.64
July	75.9	54.4	65.2	21.5	96	38	51	3.79
August	73.6	53.5	63.5	20.1	95	39	53	4.18
September	65.5	44.9	55.2	20.6	88	25	55	3.21
October	52.3	34.4	43.3	17.9	82	15	55	3.93
November	41.7	24.9	33.3	16.8	64	16	64	4.21
December	27.0	9.0	18.2	18.3	58	-31	54	3.62
Year	75.9	2.8	40.3	....	97	-34	55	43.71

HALIFAX.

[Latitude 44° 39′, longitude 63° 36′; height, 97 feet.]

January	30.9	13.1	22.0	17.8	55	16	61	5.63
February	31.6	13.9	22.7	17.7	50	-17	59	4.94
March	36.5	20.8	28.7	15.7	55	- 9	64	5.15
April	46.6	29.9	38.2	16.7	76	7	61	4.00
May	58.4	38.9	48.7	19.5	88	24	62	4.48
June	68.2	47.0	57.6	21.2	93	33	61	3.68
July	73.9	54.4	64.2	19.5	93	41	58	3.43
August	74.3	55.4	64.8	18.9	93	42	57	3.96
September	67.6	48.8	58.2	18.8	85	32	53	3.53
October	56.2	39.8	48.0	16.4	80	23	54	5.21
November	44.2	32.2	38.2	12.0	65	4	64	5.26
December	31.3	19.7	27.0	14.6	55	-11	64	5.52
Year	74.3	13.1	43.2	....	93	−17	60	54.74

THE CLIMATE OF KIMBERLEY

By J. R. SUTTON, M. A. (Cantab.), F. R. Met. Soc.

Kimberley is situated in the middle of the great South African tableland, in 28° 43′ south latitude and 24° 46′ east longitude, at a mean altitude of about 4,020 feet. Kenilworth is about 3 miles north-northeast of Kimberley, and 50 feet or more lower. The surrounding country is gently undulating, and, except for an occasional small garden plot here and there, is altogether uncultivated. It is, generally speaking, poor grass land, and carries no timber beyond a few thorn bushes. Kenilworth, however, is thickly wooded with gum and pepper trees artificially irrigated with the waste water from the diamond mines and storm water stored in various reservoirs.

Meteorological observations, sometimes good (and often inferior), have been made at a second-order station in Kimberley by voluntary observers for the Cape Colony meteorological commission for about twenty years. A good series of second-order observations was made by the late G. J. Lee for ten or twelve years at his own station. There are some very good rainfall registers, one by F. W. Matthews extending without a break from 1877 to the present time. A first-order meteorological observatory under my charge has been in existence now for about eight years at Kenilworth, equipped with high-grade instruments for recording and registering the usual meteorological elements. Unfortunately, the sites of the different stations, either in Kimberley or Kenilworth, are not of the best. It is to be hoped that in the near future a first-class physical observatory may be established in a more open situation, so as to take full advantage of the excellence of the geographical site. But with a meteorological commission indifferent, nay almost openly hostile, to any such plan, it is not to be expected that the Cape government will do its obvious duty and start one.

CLOUD

From 1897 to 1899 the cloudiness of the sky was observed three times daily, namely at VIII, XIV, XX. After 1899 the observations were taken six times daily at every three hours from VIII to XXIII. The mean results are, for the first series:

TABLE 1.—*Percentage of cloud.*[a]

	VIII.	XIV.	XX.	Mean.
				Per cent.
January	43	57	45	48
February	31	43	44	39
March	34	42	35	37
April	31	40	31	34
May	31	31	19	27
June	14	13	10	12
July	20	13	13	15
August	23	23	12	19
September	24	20	15	20
October	27	34	24	28
November	21	35	26	27
December	28	45	35	36
Year	27	33	26	28

[a] 100 per cent signifies a sky completely obscured by cloud.

And for the second series:

TABLE 2.—*Percentage of cloud.*

	VIII.	XI.	XIV.	XVII.	XX.	XXIII.	Mean.
							Per cent.
January	25	31	42	41	33	30	34
February	37	32	51	53	46	42	44
March	31	31	44	38	34	29	34
April	29	27	37	33	28	23	30
May	19	19	20	18	12	16	17
June	25	23	22	20	17	14	20
July	22	19	21	18	13	11	17
August	18	15	18	17	12	12	15
September	29	31	37	35	20	20	29
October	30	34	37	36	30	27	32
November	22	27	33	30	18	18	25
December	29	33	47	43	39	31	37
Year	26	27	34	32	25	23	28

Thus at corresponding hours in each series the results are nearly the same. The monthly means of both are combined in Table 3, which gives also the greatest and least cloudiness in each month during the seven years.

TABLE 3.—*Percentage of cloud.*

	Monthly mean.	Monthly maximum.	Monthly minimum.
	Per cent.	*Per cent.*	*Per cent.*
January	40	59	30
February	42	51	29
March	35	41	28
April	32	45	24
May	21	30	8
June	17	25	9
July	17	32	6
August	17	25	12
September	25	36	12
October	31	48	22
November	26	32	16
December	37	41	33
Year	28	59	6

We see from these results that, considering the mean of the year, the sky is most clouded during the afternoon; but that the afternoon skies of the winter months tend to clearness. We shall see later on that

this is largely due to the annual variation of cumulus. There are probably two maxima of cloud in the year—one early in February, the other in October.

Table 4 shows the annual variation of the number of times each of the principal classes of cloud have been observed in four years, irrespective of the percentage of sky clouded.

TABLE 4.—*Annual variation of cloud types.*

	High level clouds.	Stratiform clouds.	Cumulus.	Nimbus.	Total.
January	83	62	325	45	515
February	66	55	367	51	539
March	60	74	308	57	499
April	100	77	238	48	463
May	97	37	143	7	284
June	132	33	130	17	312
July	113	41	97	9	260
August	83	13	162	6	264
September	150	66	186	19	421
October	155	114	204	34	507
November	110	70	229	18	427
December	84	83	361	46	574
Year	1,233	725	2,750	357	5,065

In this table the high-level clouds include cirrus, cirro-cumulus, and alto-cumulus; the stratiform clouds are cirro-stratus, cumulo-stratus, and stratus.

It appears that the high-level clouds are seen most often in winter and at the beginning of summer. Relatively, also, cirriform clouds are much the more numerous in winter. Cumulus, on the other hand, prevails in summer, both relatively and absolutely. The annual variation of stratiform cloud is of peculiar interest. There is a maximum in April, and a very marked one in October. As it happens, if we compute the mean monthly altitudes of the first plane of condensation from the known mean temperatures of the air and of the dew-point, we shall find them lower in April and October than in any of the other months.

The diurnal variation of the different classes of cloud is important. It is given below in Tables 5, 6, 7, and 8 in terms of the number of times each was seen in four years.

TABLE 5.—*Diurnal variation of high-level cloud.*

	VIII.	XI.	XIV.	XVII.	XX.	XXIII.
January	21	28	12	9	8	5
February	15	25	14	8	3	1
March	16	18	6	10	3	7
April	22	21	18	21	9	9
May	22	27	17	17	6	8
June	27	26	27	26	16	10
July	23	27	18	24	11	10
August	12	16	16	22	12	5
September	29	34	28	28	15	16
October	34	41	22	23	18	17
November	24	23	22	21	11	9
December	21	27	13	6	6	11
Year	266	313	213	215	118	108

TABLE 6.—*Diurnal variation of stratiform cloud.*

	VIII.	XI.	XIV.	XVII.	XX.	XXIII.
January	12	5	7	12	9	17
February	15	1	4	13	11	11
March	10	9	8	14	15	18
April	12	10	8	16	13	18
May	5	3	3	11	7	8
June	5	2	2	11	6	7
July	10	1	6	8	8	8
August	3	2	3	3	1	1
September	10	8	9	17	12	10
October	17	7	18	24	27	21
November	12	5	12	14	13	14
December	21	4	9	20	8	21
Year	132	57	89	163	130	154

TABLE 7.—*Diurnal variation of cumulus.*

	VIII.	XI.	XIV.	XVII.	XX.	XXIII.
January	27	58	84	65	55	36
February	37	70	93	69	55	43
March	39	63	76	59	40	31
April	30	42	66	49	32	19
May	14	23	40	31	20	15
June	16	28	36	26	12	12
July	12	15	26	23	13	8
August	28	25	38	30	21	20
September	17	39	54	43	18	15
October	19	51	58	36	21	19
November	27	51	61	46	29	15
December	36	79	85	73	56	32
Year	302	544	717	550	372	265

TABLE 8.—*Diurnal variation of nimbus.*

	VIII.	XI.	XIV.	XVII.	XX.	XXIII.
January	4	4	6	15	10	6
February	3	1	5	17	14	11
March	5	5	9	12	16	10
April	5	4	6	11	13	9
May	1	1	....	2	1	2
June	2	2	1	2	4	6
July	2	2	3	....	....	2
August	....	2	....	1	....	3
September	2	....	1	5	5	6
October	3	2	7	11	6	5
November	1	1	4	7	3	2
December	2	....	10	11	14	9
Year	30	24	52	94	86	71

Thus the high-level clouds are most often seen in the forenoon. The numbers for the two night hours (XX and XXIII) are certainly somewhat too small, because detached cirri are difficult to see at night and must frequently escape observation. The decrease in the frequency of clouds of a stratus type from XVII to XX perhaps admits of a similar explanation, for these clouds, lying so much above the horizon, are even more difficult to detect than the ubiquitous cirrus. I am inclined to suspect, moreover, that the frequency of the high-level clouds given at XI and XIV is somewhat too great, the usual observer at those hours sometimes noting cirrus when false cirrus (or blown-out cumulus) may be in sight. Cumulus reaches its maximum fre-

quency near the hottest hour of the day. The stratiform clouds, on the other hand, are seen less frequently at midday than at other times; from which it is clear that an upcast of heated air is not concerned in their formation. Nimbus reaches its maximum frequency at sunset, when, as we shall see later, thunderstorms are most prevalent.

The total frequency of cloud during the four years considered is:

TABLE 9.—*Total frequency of cloud.*

VIII	730
XI	938
XIV	1,071
XVII	1,022
XX	706
XXIII	598

where the quantities stand in the same order of relative magnitude as those of the cloud percentages of Table 2.

The direction of motion of the cloud currents over Kimberley is mainly from some westerly direction. Table 10 gives the numbers observed from each of eight points during four years.

TABLE 10.—*Directions from which the clouds come.*

N	66
NE	12
E	4
SE	4
S	13
SW	37
W	253
NW	200

The resultant direction is 66° 45′ N. W., or very nearly west-northwest. It is to be remembered, however, that only the more rapidly moving clouds are accounted for in this table. There are no instruments at this observatory for observing the movements of the slower clouds.

SUNSHINE

Table 11 gives the mean hourly sunshine for the ten years 1894–1903 as obtained from the records of a Jordan twin hemicylinder recorder.

TABLE 11.—*Mean duration of sunshine in minutes per hour.*

Hour ending.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
VI	22.2	10.0	0.8	......	......	......	......	......	......	4.4	20.5	27.7
VII	45.5	41.7	34.9	15.9	2.8	......	0.5	7.5	26.3	43.6	49.2	46.8
VIII	48.4	45.5	48.0	47.1	46.1	41.2	43.1	49.0	51.1	50.2	52.4	50.0
IX	50.2	48.1	49.1	50.3	51.2	53.2	54.6	53.9	53.3	53.0	53.8	51.1
X	50.8	48.5	50.2	52.1	52.4	53.6	56.0	54.3	54.9	53.7	54.9	52.5
XI	51.1	50.0	49.7	52.0	53.4	55.0	56.3	55.4	55.3	53.8	54.4	52.0
Noon	50.7	49.4	48.6	51.8	53.3	54.7	56.0	55.7	55.0	52.0	52.5	50.6
XIII	48.7	48.0	47.2	50.3	53.0	54.9	56.0	55.5	54.6	50.8	52.4	48.8
XIV	45.4	45.6	44.8	50.2	53.3	55.1	56.0	55.8	54.1	50.9	50.9	46.8
XV	43.0	43.7	44.3	47.5	52.8	55.4	55.8	54.8	53.6	50.7	49.4	43.6
XVI	41.0	40.1	42.4	46.8	51.5	54.3	55.0	53.7	51.5	48.5	47.8	42.4
XVII	39.9	37.3	39.5	42.9	45.1	41.2	44.3	48.9	50.2	47.2	45.4	40.6
XVIII	37.5	32.7	29.7	16.3	3.7	......	.5	9.4	27.1	41.3	43.1	39.4
XIX	19.7	8.1	.6	......	......	......	......	......	......	4.6	19.1	23.1
Average percentage.	72	70	72	77	81	84	85	83	82	79	79	74

The bottom line of Table 11 gives the monthly average percentage of the optimum. A horizontal sun (i. e., at rising and setting) makes no impression upon the photographic paper, at any rate not more than is made by diffused daylight, so that on every sunny day some minutes are lost from each end of the record. Some observatories in America, I believe, allow for this by computing the ratio of the total quantity recorded to a quantity something less than the optimum, which may be called the maximum capacity of the instrument. This method would give monthly mean percentages 1 or 2 per cent greater than those of Table 11. There is a good deal of uncertainty, however, amounting perhaps to a value of 2 per cent in extreme cases, due in the first place to the variation in the sensitiveness of the photographic paper and in the second place to the discoloration of the general surface of the paper by diffused daylight. A Campbell-Stokes recorder gives a longer record just after sunrise and before sunset, when the sky is clear, than a Jordan instrument does, but it has no other advantages. Of course, in all cases and with any instrument, much depends upon what is understood by "sunshine."

The sunniest hour of the day is X–XI, though in the winter months, June–August, there is also a tendency to a second maximum in the second or third hour after noon.

Sunless days are very rare, only twenty-six being on record in ten years. There are plenty of months without a single sunless day. The year 1894 was exceptional in this respect, with seven days upon which the sun did not show itself; in February, indeed, there were actually three consecutive sunless days, which is a record probably not likely to be soon beaten. Table 12 shows the total number of days in ten years upon which the sunshine was less than one hundred minutes.

TABLE 12.—*Number of very cloudy days in ten years.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Sunless	5	5	2	3	1	2	3	1	......	2	1	1	26
Less than 10 minutes	1		2	1	3	1	......	......	......	2	......	1	11
10 to 100 minutes	2	6	8	9	2	5	2	6	4	6	2	1	53

INSOLATION

The mean and extreme maximum temperatures in the sun at Kenilworth, from observations made during the seven years 1897–1903 with a blackened bulb thermometer in vacuo, are given in Table 13, below:

TABLE 13.—*Maximum temperatures in the sun.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
Mean	151.0	152.7	143.8	135.3	124.7	118.8	118.8	127.3	136.3	141.6	148.8	153.3	137.8
Extreme	170.5	168.5	159.0	148.7	139.6	131.1	130.2	144.1	156.1	166.3	168.8	170.5	170.5

The extremes are very nearly the same as those observed in corresponding latitudes in South America, the range at Córdoba for the twenty years 1881–1900 being from 131° in June to 174° in November.[a]

The Kenilworth annual means are very constant, varying only from 136° to 140°.

RADIATION

The mean and extreme minimum temperatures over grass, from observations made during the eight years 1896–1903, are given in Table 14, together with the extreme minima on grass from observations made during the five years 1899–1903. The former are obtained from the readings of a spirit thermometer, with a spherical bulb, placed on a stand which raises it about three inches above short grass. The latter from the readings of a similar thermometer lying on the grass.

TABLE 14.—*Minimum radiation temperatures.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
Mean minimum over grass	57.2	58.0	54.0	47.3	38.0	31.5	30.7	35.8	40.9	47.0	49.9	57.4	45.6
Extreme minimum over grass	39.1	40.0	36.9	31.1	21.9	20.5	18.0	18.4	24.5	29.2	31.3	44.8	18.0
Extreme minimum on grass	40.9	43.9	34.3	28.0	20.1	14.0	12.5	19.0	20.8	27.1	30.8	41.3	12.5

Owing to the shortness of the period some of the numbers in the third line are greater than those in the second. Comparing Tables 13 and 14, it appears that the total range of temperature observed, from the maximum in the sun to the minimum on grass, is 158°.

SHADE TEMPERATURE

Within the last year or two I have published daily values of the mean maximum and minimum shade temperature of Kimberley for the ten years 1888–1897; also the maximum and minimum registered on every day (with a gap here and there) during the eighteen years 1880–1897. In Tables 15 and 16 monthly summaries of these are quoted, with the addition of the mean monthly values of the temperatures registered at Kenilworth during the eight years 1896–1903, and also the extremes. And finally monthly means and extremes, for Kimberley and Kenilworth together, for the twenty-four years 1880–1903, i. e., eighteen years of Kimberley temperature and six years of Kenilworth.

[a] Davis, W. G., Climate of the Argentine Republic, p. 40. There are registered maxima at Córdoba of 65° C. (=149° F.) and 68.7° C. (=156° F.) in June and July, 1875, respectively. These are 18° F. higher than those of the same month in any other year, and seem to need confirmation.

TABLE 15.—*Mean maximum and minimum temperatures of the air.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
KIMBERLEY.	°	°	°	°	°	°	°	°	°	°	°	°	°
Maximum 1888–1897	92.0	88.9	84.0	75.4	67.4	63.3	64.3	70.5	78.3	85.1	89.9	92.7	79.3
Minimum 1888–1897.	60.6	60.1	57.7	50.5	42.4	37.5	36.3	40.7	45.0	51.8	55.8	59.3	49.8
Maximum 1880–1897	91.8	89.5	83.6	76.2	68.0	63.7	64.3	69.7	78.5	84.5	88.9	92.0	79.2
Minimum 1880–1897.	61.0	60.	56.9	50.1	42.5	37.3	35.8	40.0	45.8	51.8	55.8	59.5	49.8
KENILWORTH.													
Maximum 1896–1903	89.0	89.6	84.1	77.6	70.4	64.7	65.9	71.9	78.4	82.4	86.3	89.8	79.2
Minimum 1896–1903.	61.3	61.7	57.7	51.4	42.4	35.9	35.4	40.1	45.5	51.3	54.5	61.2	49.9
TOTAL.													
Maximum 1880–1903	91.1	89.4	83.6	76.3	68.6	64.0	64.6	70.2	78.4	83.6	88.3	91.5	79.1
Minimum 1880–1903.	61.0	61.0	57.0	50.2	42.3	36.9	35.7	39.9	45.8	51.5	55.5	59.8	49.7
Mean 1880–1903	76.0	75.2	70.3	63.2	55.5	50.4	50.2	55.0	62.1	67.5	71.9	75.6	64.4

TABLE 16.—*Extreme temperatures of the air.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
KIMBERLEY.	°	°	°	°	°	°	°	°	°	°	°	°	°
Maximum 1888–1897	108.5	106.2	100.6	92.2	82.7	76.6	80.0	85.6	96.6	103.0	107.5	107.3	108.5
Minimum 1888–1897.	45.5	48.5	41.3	35.0	27.3	25.0	20.0	26.5	25.5	30.3	37.6	42.5	20.0
Maximum 1880–1897	108.5	106.2	100.6	92.8	82.7	78.8	80.0	85.6	96.6	103.0	107.5	107.3	108.5
Minimum 1880–1897.	45.5	44.7	37.3	31.6	27.3	25.0	20.0	23.9	25.5	30.3	37.6	42.5	20.0
KENILWORTH.													
Maximum 1896–1903	102.0	101.4	97.0	92.2	83.0	78.5	76.8	84.0	94.3	96.7	100.6	102.1	102.1
Minimum 1896–1903.	44.0	46.3	43.0	37.1	26.9	25.2	23.5	22.2	28.8	34.9	37.9	48.0	22.2
TOTAL.													
Maximum 1880–1903	108.5	106.2	100.6	92.8	83.0	78.8	80.0	85.6	96.6	103.0	107.5	107.3	108.5
Minimum 1880–1903.	44.0	44.7	37.3	31.6	26.9	25.0	20.0	22.2	25.5	30.3	37.6	42.5	20.0
Range 1880–1903	64.5	61.5	63.3	61.2	56.1	53.8	60.0	63.4	71.1	72.7	69.9	64.8	88.5

The highest shade temperature on record is 108.5° (in January). It appears that a temperature exceeding 100° is possible in any one of the six months October–March, and that nearly 80° is possible at midwinter. The lowest shade temperature on record is 20° (in July), and temperatures of the air below the freezing point are common in any of the seven months April–October.

The occasional very high temperatures of the period October to March are usually accompanied by northwesterly winds. So, as it happens, are the occasional very high temperatures of the spring months on the Natal coast. But the resemblance goes no further. The high temperatures at Durban are accompanied by a decrease in the vapor tension, and often by stratiform clouds; the high temperatures at Kimberley are, as a rule, accompanied by an increase of vapor tension and by cumulus. Accepting Hann's view that the hot winds of Durban (Natal) are true Föhnwinde,[a] then they are descending currents of air heated mechanically, by compression; whereas the hot

[a] See J. Hann, Meteorologische Zeitschrift, January, 1904, p. 42.

winds of Kimberley are ascending currents from the highly-heated surface of the ground.

A comparison of the Kimberley maximum and minimum temperatures for the ten years 1888–1897 with those for Kenilworth for the eight years 1896–1903 is interesting. The Kimberley maxima are higher in summer and lower in winter than the Kenilworth maxima. This is not due to any great extent to the fact that different periods are taken at the respective places. The reason is that southerly winds are rather more frequent in winter and northerly winds in summer, and that a southerly wind raises the maximum shade temperature of Kenilworth, whereas a northerly wind raises that of Kimberley, relatively one to the other.

But the great interest of Table 15 is to be found in the peculiarity that the mean maxima are not highest in January and February nor lowest in July and August. There is no very great lagging or accumulation of temperature consequent upon the noon altitude of the sun. In fact the mean maximum temperature proper to any date may be expressed as a linear function of the sun's altitude.[a]

Table 17 gives a comparison between the average maximum and minimum temperature of each month and the monthly means of hourly readings for the same six years (1898–1903) in each case.

TABLE 17.—*Monthly mean temperatures.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
½ (M + m)	75.2	75.4	70.5	63.5	56.1	50.3	50.4	55.6	62.0	65.8	70.4	75.4	64.2
Hourly mean	74.4	74.2	69.2	62.1	54.6	48.7	48.9	54.5	61.1	65.4	70.4	74.9	63.2
Difference	+0.8	1.2	1.3	1.4	1.5	1.6	1.5	1.1	.9	.4	.0	.5	1.0

The average of the daily extremes, therefore, is exactly 1° higher than the mean of the hourly readings, the difference ranging from zero in November to 1.6° in June. The sequence of differences makes a very regular curve, its most marked feature being the rapid fall in the spring months.[b]

EARTH TEMPERATURES

Monthly mean values of earth temperatures under a bare sand surface at five different depths, from 1 inch to 6 feet, are given in table 18.

[a] Upon any date let T be the mean maximum temperature, Z the sun's zenith distance, R the sun's semidiameter, each being expressed in any units, then $T = AR^2 \cos Z + B$, where A and B are constants to be determined.

[b] Hann has drawn attention to this fact in the Meteorologische Zeitschrift for February, 1903.

TABLE 18.—*Monthly mean temperatures of the soil at 8 p. m.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1 inch:	°	°	°	°	°	°	°	°	°	°	°	°	°
Minimum	64.6	64.7	58.2	51.7	41.9	35.2	33.9	38.4	44.6	52.0	55.3	63.8	50.3
Maximum	120.4	113.5	104.7	91.8	84.9	73.6	78.0	92.3	97.3	108.5	121.6	121.4	100.7
1 foot	86.2	86.4	79.0	70.2	60.8	53.9	52.0	59.0	67.1	75.4	82.0	86.6	71.6
2 feet	82.0	82.6	77.1	70.0	61.8	54.9	52.6	57.5	64.0	71.2	77.0	81.3	69.3
4 feet	77.9	78.7	76.4	72.2	66.7	60.8	57.7	58.9	62.5	67.5	71.8	75.5	68.9
6 feet	74.6	75.6	75.1	72.8	69.4	65.1	61.9	61.1	62.7	65.8	69.7	71.9	68.8

Maximum and minimum earth temperatures at a depth of 1 inch have only been observed for three years; but the results for greater depths are for the six years 1898–1903. There is not any diurnal variation below a depth of 3 feet, whereas above it a correction must be applied to the readings obtained at a given hour in order to deduce the mean. At 8 p. m. the temperature at a depth of 1 foot is almost at its maximum; but the diurnal heat wave does not penetrate to a depth of 2 feet until perhaps ten hours later. The following are the mean annual temperatures at different hours of observation, shown by thermometers at depths of 1 and 2 feet:

	1 foot.	2 feet.
	°	°
VIII	67.2	69.4
XIV	68.7	69.0
XX	71.6	69.3
Average	69.2	69.2

Observations are not yet sufficiently numerous to give the mean dates when the temperatures just beneath the surface of the ground are highest or lowest. It seems likely, however, that they fall very near the corresponding dates for the highest and lowest temperature of the air. It is interesting to observe how the annual temperature wave gets later as it penetrates deeper, taking, indeed, at Kimberley two months to reach a depth of 6 feet.

BAROMETRIC PRESSURE

Mean monthly barometric conditions are given in table 19, and also, for comparison, the velocity of the wind.

TABLE 19.—*Mean monthly barometric pressure conditions and wind velocity.*

	Jan.	Feb.	Mar.	Apr.	May.	June.
VIII and XX:						
1890–1897, inches	26.035	26.066	26.121	26.179	26.217	26.269
1898–1903, inches	26.015	26.088	26.095	26.161	26.229	26.293
1890–1903, inches	26.026	26.075	26.110	26.173	26.222	26.279
Hourly readings, 1898–1903, inches	26.008	26.075	26.080	26.145	26.210	26.277
Wind velocity, 1898–1903, miles per hour	6.9	6.3	5.2	4.5	4.8	4.6

TABLE 19.—*Mean monthly barometric pressure conditions and wind velocity*—Continued.

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
VIII and XX:							
1890-1897, inches	26.273	26.217	26.169	26.116	26.079	26.050	26.149
1898-1903, inches	26.262	26.233	26.195	26.116	26.054	26.041	26.149
1890-1903, inches	26.268	26.224	26.180	26.116	26.068	26.046	26.149
Hourly readings, 1898-1903, inches	26.245	26.215	26.178	26.094	26.035	26.026	26.132
Wind velocity, 1898-1903, miles per hour	4.9	5.4	6.5	7.0	6.8	6.4	5.8

In this table the first line gives the barometric pressures observed twice a day at Kimberley, but approximately reduced to the level of Kenilworth. The second line gives Kenilworth observations. The third line combines the first and second into a mean of fourteen years. It is interesting to compare the fourth line (giving the means of hourly observations) with the second. From a consideration of each series it appears that the greatest mean daily pressure should be looked for near the end of June, and the least early in January, the actual epochs falling very little behind those of maximum temperature.

The highest pressure observed at Kenilworth at any time during the six years 1898–1903 was 26.580 inches, the lowest 25.615 inches. In July, 1894, there was a pressure of 26.508 inches observed at Kimberley, which would probably have been nearly 26.6 inches at Kenilworth; from which it seems likely that the total range of pressure ever likely to be observed here is just about 1 inch.

WIND

The wind is generally light. Velocities of 30 miles per hour seldom occur; velocities of 40 miles per hour, for an hour, scarcely ever, although there are records of gusts exceeding 10 pounds, and one indeed of 16 pounds per square foot. The greatest average velocity known for any twenty-four hours falls short of 18 miles per hour; i. e., it is less even than the mean velocity during any month round the coast of South Africa. There are calms at Kimberley occasionally, but they seldom last many hours. The smallest known day's run of the anemometer was 27 miles, in June, 1903.

Dusty days are frequent during the second half of the year. The dust is usually raised by gusty winds (not necessarily of great strength) from the northwest quadrant. These form a diurnal phenomenon, commencing, as a rule, just after sunrise and ceasing at sunset. A dusty night is rare.

MOISTURE

The mean temperatures of the wet bulb and of the dew-point are given in Table 20. They call for little comment, but should be studied in conjunction with the corresponding monthly values of rainfall and thunderstorms to be considered later.

TABLE 20.—*Monthly mean moisture conditions.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Wet bulb, degrees..	60.9	61.7	59.7	54.6	46.4	41.3	41.2	44.0	48.2	51.9	54.7	60.0	52.0
Dew-point, degrees.	51.4	53.0	52.7	48.6	39.0	33.9	33.3	34.5	37.8	41.4	43.1	49.6	43.2
Humidity, per cent.	50.2	52.7	60.5	65.0	59.3	59.6	58.2	50.2	46.0	46.0	41.8	46.1	53.0

RAINFALL

Monthly means of rainfall and of thunderstorms will be found in Table 21.

TABLE 21.—*Monthly means of rainfall, thunder, and thunderstorms.*

	Jan.	Feb.	Mar.	Apr.	May.	June.
Mean rainfall, inches	2.745	2.728	3.214	1.506	0.787	0.391
Maximum in one month, inches	8.430	6.348	8.460	3.855	2.016	1.303
Maximum in one day, inches	2.810	2.140	2.375	1.372	1.546	.738
Mean number of rain days	9.7	10.3	11.0	7.2	4.2	2.5
Average per rain day, inches	.284	.265	.292	.209	.187	.156
Mean hours of thunderstorm	17.4	15.2	16.2	12.5	1.4	2.2
Mean hours of thunder	8.0	4.2	6.7	5.0	.8	....

	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Mean rainfall, inches	0.335	0.351	0.881	1.182	1.711	2.409	18.240
Maximum in one month, inches	1.605	1.672	5.950	6.097	7.030	6.969	8.460
Maximum in one day, inches	1.015	.970	4.520	3.442	4.250	3.165	4.520
Mean number of rain days	1.8	2.3	2.7	5.6	6.8	8.6	72.7
Average per rain day, inches	.186	.153	.326	.211	.252	.280	.251
Mean hours of thunderstorm	3.2	1.9	5.2	11.0	13.4	18.2	117.8
Mean hours of thunder	.2	.0	.1	2.1	1.8	5.4	34.3

The rainfall values in Table 21 are derived from observations taken by different observers in and about Kimberley during the twenty-seven years 1877–1903. The number of hours of thunder and thunderstorm are from eye and ear observation at Kenilworth during the six years 1898–1903. The annual rainfall, averaging 18¼ inches, fluctuates between 8 and 35 inches. March is the wettest month; July the driest. The greatest fall in any one month was 8.46 inches in March, 1881. The greatest fall in any twenty-four hours ending at 8 a. m. was 4.52 inches in September, 1902. The chance of a rainy day is greatest in February, least in July. The average fall upon a rainy day is greatest in September. September, however, is remarkable for the character of its rainfall; while the actual chance of rain is scarcely greater than that of August, the average fall is more than twice as great; indeed, more than a half of the whole September rain in twenty-seven years has fallen in daily quantities exceeding 1 inch each.

October is interesting and, so far as its meteorological elements go, quite different from any other month. Its rain, falling from low-lying stratiform clouds, is not heavy compared with that of September and November, there being only one October day on record upon which

the fall exceeded 1 inch. It has a fair share of electrical phenomena, albeit this is not necessarily accompanied by rain in any month. Its humidity, as compared with that of September (see Table 20), is worth attention.

Winter thunderstorms are not common, but in summer they occur every third or fourth day on an average. Hail comes occasionally, now and then inflicting great damage over small areas. Snow is very rare; twice, perhaps, in the history of Kimberley snow has fallen to remain for a few hours on the ground. Dew comes chiefly during damp nights in the autumn, and is rarely seen in the spring or summer before Christmas.

TABLE 22.—*Annual means in hourly values.*

Hour.	Dry bulb.	Wet bulb.	Dew point.	Humidity.	Barometric pressure.	Wind.	Rain frequency.	Thunderstorm frequency.
	°	°	°	*Per cent.*	*Inches.*	*Miles per hour.*	*Hours per annum.*	*Hours per annum.*
Midnight	56.2	48.9	42.1	61.8	26.140	....	....	....
I	55.1	48.4	42.1	64.3	26.136	4.8	12	2.6
II	53.9	47.9	42.1	66.7	26.132	4.7	13	1.6
III	53.0	47.4	41.9	68.0	26.129	4.5	12	1.0
IV	52.2	47.0	41.6	69.3	26.131	4.4	11	0.8
V	51.3	46.6	41.6	71.3	26.138	4.3	11	0.5
VI	51.4	46.8	42.1	72.2	26.150	4.3	10	1.2
VII	53.6	48.1	42.9	69.5	26.162	4.6	9	1.9
VIII	59.2	51.0	44.0	59.8	26.172	5.4	8	1.3
IX	64.7	53.6	45.0	51.1	26.175	6.3	8	1.8
X	68.9	55.3	45.0	44.8	26.173	7.1	7	1.6
XI	72.3	56.5	44.8	39.9	26.161	7.4	7	2.0
Noon	74.7	57.1	44.5	36.7	26.142	7.6	8	3.9
XIII	76.3	57.4	44.1	34.3	26.121	7.8	10	7.5
XIV	77.0	57.5	43.9	33.5	26.101	7.8	14	11.0
XV	76.9	57.3	43.5	33.3	26.091	7.7	18	14.1
XVI	75.9	56.8	43.3	34.4	26.085	7.4	20	18.0
XVII	72.6	56.0	44.0	39.6	26.087	6.7	20	14.1
XVIII	68.1	54.3	43.8	45.5	26.096	5.8	19	15.0
XIX	64.5	52.9	43.7	50.3	26.109	5.1	20	14.3
XX	62.2	51.9	43.2	52.9	26.123	5.0	20	10.5
XXI	60.3	50.8	42.7	55.4	26.133	5.1	19	9.1
XXII	58.7	50.1	42.4	57.6	26.140	5.0	17	6.3
XXIII	57.4	49.5	42.2	59.4	26.141	5.0	17	7.1
Midnight	56.2	48.9	42.1	61.8	26.140	4.9	16	4.9
	63.2	52.0	43.2	53.0	26.132	5.8	326	152.1
Maximum day	84.9	69.4	66.4	96.4	26.525	17.9	....	....
Minimum day	36.1	31.1	20.3	24.5	25.752	1.1	....	....

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The publication of the results of our meteorological at last nearly completed, and the five reports already pu hourly meteorological observations—on the clouds, on s on the optical phenomena of the atmosphere, and on the lis -make it possible to judge of the contribution to anta ogy brought back by the Belgian antarctic expedition.

The study of the results which we have obtained conv all this work is only the wedge started into the unkno this critical point it is fortunate that the expedition of th followed so closely by those others which have in so enriched our knowledge by great geographical discoveri of scientific material, the publication and discussion unfortunately take many years. But notwithstandin tance of the results obtained by the *Belgica*, *Southern Discovery*, *Antarctic*, and the *Scotia*, I consider the w new acquisitions to science as only work of orientati work.

Taking into consideration the modern ideas and scie ments of to-day, it is sufficient to place ourselves in the Maury held forty years ago to be convinced that as far a is concerned the observations already collected are sti cient; that they form an acquisition to science whic it may be, must be considered as only provisory. W satisfied very long with observations obtained by no n antarctic stations and the conclusions which may be them.

So it is evident that sooner or later we must go on.

The first effort to unveil the mysteries of the Anta realized, but the great work is still to be done. This, conviction.

If all the expeditions, in whose happy return we rej tered simultaneously and if they had been seconded by s could have been easily installed on the subantarctic isl cussion of the whole of those observations would p revealed not only the exact position of the isotherms an all around the south polar ice cap, but also the course of and perhaps, even, the laws of the general circulation phere in the Antarctic; whereas, on the contrary, becau ditions in which the several winterings were made, we sh climatological data and a series of questions simply but not resolved in everything concerning the dyn atmosphere.

Now, the interest which antarctic meteorology present sacrifices and new efforts, on the condition that in the or new expeditions the appeal of Maury for an effective

cooperation be taken into consideration as well as the ideas which were developed later by Weyprecht, after his return from Franz-Josef Land, and which led to the memorable international expeditions and the remarkable scientific results obtained in the years 1882 and 1883.

The thing desired is to have as great a number of stations as possible working, all simultaneously, not only with a view of accumulating the data resulting from the ordinary hourly meteorological observations, but, first of all, with a view of enriching our knowledge of the meteorological conditions of the upper regions of the atmosphere by experiments with self-registering instruments mounted on kites and by continuous study of the clouds, especially of their height and the direction and speed of their movements.

The stations must be sufficiently near one another to permit, after the return of the expeditions, the drawing of daily synoptic maps—or even hourly, for the most interesting cases—and it is only under such conditions that we shall succeed in learning the usual tracks of the cyclones which are observed in the subantarctic regions all around the polar ice cap, and about the movements of which we have no knowledge, for we do not even know whether they converge toward the pole, following a spiral track, or whether, on the contrary, the depressions are formed on the borders of the ice (where the isotherms are very close together) and, leaving the polar circle, pass northwestward. The clouds, as well, must be studied very carefully, so that the distribution of the systems of clouds in the barometric depressions may be established exactly, and in this respect the antarctic regions may give us very valuable information.

From the detailed study of the clouds that Dobrowolski undertook and carried out on board the *Belgica*, we can deduce that those cloud masses which he has called "systems of clouds" form huge layers, generally discontinuous (at least at their borders), where the undulations may be distinctly observed.

The clouds show us the long waves which must necessarily be formed between two layers of air sliding one over the other and between which clouds are interposed.

However, Dobrowolski's work should be continued, and the only way to bring it to a satisfactory end and to resolve the fine problems of atmospheric dynamics which are still awaiting a definite solution is to have good observers distributed at a series of stations sufficiently close together that the same system of clouds may be studied simultaneously through its whole extent. If we look forward into the question of the scientific exploration of the antarctic regions the idea of international cooperation - of the concentration of all efforts toward one and the same end - must necessarily pursue us.

It is evident that a common plan of action is necessary.

The possibility of putting into execution the desideratum that I ask

the Congress to take into consideration is offered by the existence of the subantarctic islands where the necessary stations could be established to connect the antarctic stations, properly speaking, with those of South America and Australia.

The Cape Horn region and the lands situated farther south seem to me very favorable for the establishment of a polygon of stations, the chosen places being Falkland Islands, Staten Island, one of the islands of Diego Ramírez, and the light-house of Los Evangelistas; then the South Georgia, Sandwich, Orkney, and South Shetland islands; lastly, a station on the coast of Graham Land, another at the wintering station of Nordenskjöld, for example, and two floating stations—one in the region of the drift of the *Belgica* and the other in the Weddell Sea. We would have in this way a polygon of posts of observation sufficiently large and composed at the same time of points sufficiently near together.

The expenses of such an undertaking might be counted as follows:

A ship wintering in the ice in the region of the drift of the *Belgica*, $100,000. A second ship in Weddell Sea, $100,000; a third, exploring the edge of the pack and studying the variations of the distributions of the ice and making oceanographic researches during the whole year, $100,000.

The first and second may install each a station on the antarctic lands, and the third, in two cruises, the four stations on Sandwich, Georgia, Falkland, and Shetland islands—let us count six stations at $30,000 each.

And, lastly, as for the region of Cape Horn, there is already a good meteorological station on the island Año Nuevo, near Staten Island, while that one of the light-house of Los Evangelistas would probably need a special staff and instruments, and so let us simply count Diego Ramírez, $20,000, and a mountain station, for example, on the summit of the mountain called Bonnet de la Republic, near Llopotaia, the installation and all the working expenses of which would not exceed $30,000.

The entire expenses of such an undertaking, then, would not, as you see, exceed $530,000.

If you will bear in mind that this expense would be divided between the different nations taking part in this expedition, and that aside from the meteorological work other researches, oceanographic, etc., would certainly be undertaken, you will see that the proposition which I submit to the appreciation of the congress could be easily realized, and that our knowledge of the physical conditions of the globe would be enriched by an enormous amount of new scientific data, for the acquisition of which it is worth while to sacrifice the money and necessary efforts.

In concluding, I take the liberty of asking the congress:

(1) If we must be satisfied for the time being with the results of the antarctic expeditions of the past few years, or if the scientific exploration of the subantarctic region and the South Pole must be continued;

(2) If the idea of international cooperation for the study, during one year at least, of the atmospheric conditions in the antarctic should be put into execution; and,

(3) If we are agreed upon the necessity of a new international effort for the solution of the antarctic problems, I ask the congress to nominate a committee, charged to present to the next congress (or even before that) a plan and thorough examination of the means of putting such a plan into execution.

DE LA PRÉDOMINANCE DES TOURBILLONS EN SENS INVERSE DES AIGUILLES D'UNE MONTRE DANS LES COURS D'EAU DE L'EUROPE CENTRALE ET OCCIDENTALE,

Par JEAN BRUNHES, Professeur de géographie à l'Université de Fribourg (Suisse).

Depuis quelques années nous avons attiré l'attention des géographes sur la part qui revient aux tourbillons dans l'action des eaux courantes;[a] et non seulement nos idées n'ont point été contredites, mais elles ont été confirmées par bon nombre d'observateurs, géologues et géographes.[b]

Les tourbillons des eaux courantes ont un rôle si prédominant qu'on doit en étudier avec méthode et tenter d'en définir avec précision tous les caractères.

On avait souvent affirmé qu'à la différence des tourbillons atmosphériques, les tourbillons des cours d'eau tournent indifféremment dans le sens inverse des aiguilles d'une montre (c'est-à-dire, de la gauche vers la droite ou *sinistrorsum*), ou dans le sens des aiguilles d'une montre (c'est-à-dire de la gauche vers la droite ou *dextrorsum*). Après de nombreuses observations, dont beaucoup sont consignées sur des photographies stéréoscopiques, j'ai cru pouvoir déclarer qu'il y a pour l'ensemble des cours d'eau observés, cours d'eau pyrénéens, et surtout cours d'eau alpins, un sens prédominant des tourbillons, et ce sens est le même que pour les tourbillons atmosphériques de l'hémisphère nord, c'est-à-dire, le sens inverse des aiguilles d'une montre.

Ce fait d'observation paraissait si nouveau que ma seule affirmation ne semblait pas convaincre tout le monde, et quant à mes photogra-

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[a] Voir surtout Jean Brunhes, Le travail des eaux courantes: la tactique des tourbillons. I. Ilots granitiques de la première cataracte du Nil. II. Gorges du versant nord des Alpes suisses, Mém. Soc. fribourgeoise d sc. naturelles, série: géologie et géographie, II, fasc. 4, Fribourg, 1902; voir aussi Marmites fluviales et tourbillons, Le Globe (Genève), Bulletin, XLII, 1903, pp. 85-93; et l'ensemble de mes notes et mémoires signalés dans ce dernier article.

[b] Je renvoie dans Jean Brunhes, Nouvelles observations sur le rôle et l'action des tourbillons (Le Globe, mémoires, 1904), au premier paragraphe: I. Confirmations des observations antérieures; je rappelle spécialement le mémoire d'Emile Chaix-Du Bois, Le pont des Oulles, phénomène d'érosion par les eaux courantes (Bellegarde, Ain), dans La Géographie (Paris), VIII, 15 décembre 1903, pp. 341-356, figs 44-50. J'ajoute à cet ensemble Félix Mazauric, Explorations hydrologiques dans les régions de la Cèze et du Bouquet (Gard), dans Spelunca, mars 1904 (Paris); voir notamment pp. 31-36, 39-42.

phies elles ne portaient naturellement que sur des cas isolés de tourbillons ou sur de toutes petites portions de cours d'eau, et elles ne pouvaient pas avoir une force démonstrative générale. J'ai eu alors l'idée de reprendre et de poursuivre ces observations en les coordonnant selon une méthode rigoureuse, et j'ai dressé pour tous les rapides observés des tableaux statistiques similaires et partout comparables. J'ai communiqué quelgues-unes de ces observations à l'Académie des Sciences de Paris, à la séance du 11 avril 1904, par l'intermédiaire obligeant de mon maître, M. de Lapparent;[a] et avant de discuter ces données et de les expliquer, je dois rappeler brièvement ces observations en les faisant suivre de quelques autres encore inédites.

Il est si malaisé de bien observer les phénomènes tourbillonnaires que je retiens pour mes études comparatives les seuls rapides dans lesquels les tourbillons déterminent à la surface des crêtes d'écume. Il y a bien d'autres tourbillons en profondeur que les tourbillons auxquels correspond cette écume superficielle; mais ceux-là sont les seuls dont nous puissions en vérité discerner le sens de rotation.

Il convient d'autre part de ne point faire entrer en ligne de compte les tourbillons qui sont produits par des faits artificiels, totalement étrangers à l'écoulement normal des cours d'eau, c'est ainsi que la pile d'un pont bouleverse l'écoulement régulier et crée en aval une petite zone plus ou moins calme, côtoyée de part et d'autre par les eaux plus rapides qui sont passées librement sous les arches; de part et d'autre il se produit des tourbillons qui vont toujours de la bande du courant à grande vitesse vers la zone qui échappe du courant; ils sont sur la droite *sinistrorsum* et sur la gauche *dextrorsum;* les uns et les autres se correspondent symétriquement et numériquement se compensent.

L'observation m'a démontré que nous devions exactement assimiler à la pile d'un pont toute pierre qui, dans un rapide, dépasse le niveau des eaux; cette pierre qui dépasse est dans la règle enveloppée vers l'aval de tourbillons qui, sur la droite, tournent dans le sens inverse des aiguilles d'une montre et sur la gauche dans le même sens que les aiguilles d'une montre. Tout en notant ces tourbillons dans nos tableaux, nons les avons éliminés du total à interpréter, car ils fournissent globalement à peu près autant de tourbillons *sinistrorsum* que *dextrorsum*.

Une fois ces groupes de tourbillons mis de côté, il reste un grand nombre de faits tourbillonnaires qu'on pourrait appeler les faits tourbillonnaires naturels ou normaux et pour lesquels il s'agit de savoir si les sens de rotation est indifférent.

Je choisis parmi mes observations quelques rapides, très distants les uns des autres, et autant que possible situés en des points où il soit faute de renouveler de semblables constatations.

[a] Jean Brunhes, Sur le sens de rotation des tourbillons d'eaux courantes dans l'Europe centrale. Comptes rendus de l'Acad. d. Sc., 11 avril 1904.

I. Petit rapide de la Sarine près de Fribourg (Suisse), entre le barrage de la Maigrauge et le confluent du grand ravin de Pérolles: longueur, 150 mètres environ—19 mars 1904, eaux assez hautes. Outre trois complexes tourbillonnaires dont le sens de rotation est indéterminable nous comptons, sur vingt-sept tourbillons ou complexes tourbillonnaires distincts et observables, vingt-cinq tournant dans le sens inverse des aiguilles d'une montre (soit 92.5 pour cent) et deux seulement dans l'autre sens.

II. Petits rapides du Neckar, un peu en amont de Heidelberg, sur le chenal droit du fleuve; première série de tourbillons, en face de Ziegelhäuser, Landstrasse, No. 43, sur une même bande du chenal, longue de 5 à 6 mètres; deuxième série, un peu en aval, en face des Nos. 31, 29 et 27, sur une longueur de 33 mètres—26 janvier 1904. Outre deux ensembles indéterminables nous comptons, sur vingt-six tourbillons ou complexes tourbillonnaires, vingt-cinq tournant en sens inverse des aiguilles d'une montre (soit 96.2 pour cent) et un seulement dans l'autre sens.

III. Petit rapide en aval de Traunfall (Tirol autrichien), dont la fin est à 20 mètres en amont de l'usine Traunfall-Elektricitäts Werk; lit obstrué de blocs de Schotter; sur les bords apparaît le Schlier compact -10 février 1904, eaux très basses. Outre trois tourbillons à sens indéterminable on compte, sur un total de trente et un tourbillons ou complexes tourbillonnaires, trente qui tournent en sens inverse des aiguilles d'une montre (soit 96.7 pour cent) et un qui tourne dans l'autre sens.

IV. Petits rapides de la Salzach, en face de Kuchl et 200 mètres en amont du pont de Kuchl, de forts bancs calcaires affleurent dans de lit vers l'amont et déterminent trois groupes de tourbillons, sur une longueur totale d'a peu près 75 mètres—10 février 1904; les eaux sont très basses; le niveau est à 1.20 mètres au dessous du zéro du limnomètre du pont de Golling. Outre cinq tourbillons indéterminables on observe, sur un total de cinquante-neuf tourbillons ou complexes tourbillonnaires, cinquante-cinq qui tournent dans le sens inverse des aiguilles d'une montre (soit 93.2 pour cent) et quatre seulement tournant dans le sens des aiguilles d'une montre.

V. Petit rapide de l'Adige, immédiatement en aval du pont de Mori; ce pont de fer n'a pas de pile au milieu du fleuve, les tourbillons sont donc indépendants du pont. De part et d'autre de la bande centrale des eaux il se rencontre deux petites zones de tourbillons se manifestant par des jets d'écume intermittents à la manière des feux follets; c'est pourquoi l'observation en est assez malaisée. Le groupe des tourbillons de droite est beaucoup plus important que celui de gauche—21 février 1904, eaux moyennes, plutôt basses. Outre deux complexes tourbillonnaires dont le sens de rotation est indiscernable nous comptons, sur un total de dix-sept tourbillons, seize qui tournent dans le

sens inverse des aiguilles d'une montre (soit 94.2 pour cent) et un seulement dans l'autre sens.

VI. Petit rapide de la Mur, à Graz même, immédiatement après le Franz-Carl-Brücke, entre ce pont et l'Albrecht-Brücke. Le premier de ces deux ponts repose sur une pile unique qui détermine des tourbillons assez violents de part et d'autre; ces tourbillons ne sont pas comptés, ni ceux qui viennent immédiatement après la pile sur la ligne centrale du cours. Longueur de la partie du cours observée, 110 mètres environ—18 février 1904. Outre un complexe indéterminable on compte, sur un total de vingt-cinq tourbillons ou complexes tourbillonaires, vingt-trois *sinistrorsum* (soit 92 pour cent) et deux *dextrorsum*.

VII. Petit rapide du Tessin, au sortir de la gorge de Piottino, entre Rodi-Fiesso et Faido (Val Leventina)—24 février 1904. Dans la gorge même de Piottino les tourbillons sont indiscernables (voir plus loin), et par ailleurs les eaux sont très basses et le lit est encombré de gros blocs qui dépassent. Dans le petit rapide, plus calme, qui suit les rapides de la gorge proprement dite, on peut reconnaître quelques tourbillons outre ceux, bien entendu, qui se produisent en aval des pierres et des blocs. Longueur de la partie observée, 40 mètres. Je distingue et note trois tourbillons isolés et cinq complexes tourbillonnaires, et tous les huit tournent dans le sens inverse des aiguilles d'une montre.

En somme, dans tous les petits rapides de l'Europe centrale dont je viens de résumer les observations, il y a toujours plus de 90 pour cent des tourbillons qui tournent dans le sens inverse des aguilles d'une montre.

Ces remarques qui se rapportent aux eaux courantes superficielles ont été étendues d'une manière très intéressante aux eaux courantes souterraines, par Monsieur E. A. Martel. Il écrit en effet à propos du tunnel d'Oupliz-Tsiké, exploré lors de sa récente campagne dans la Russie méridionale. "Le sens de l'hélice du tunnel d'Oupliz-Tsiké est à l'inverse de celui des aiguilles d'une montre, conformément à la majorité des cas observés par M. Jean Brunhes pour les tourbillons des vallées en travail d'érosion."[a]

Pourquoi les tourbillons des cours d'eau tournent-ils de préférence de la droite vers la gauche? Ne peut-on pas rattacher ce fait à la même cause à laquelle on rattache la prédominance des tourbillons atmosphériques de même sens? Dans un mémoire que nous voulons

[a] Martel, E. A., Sur le gouffre-tunnel d'Oupliz-Tsiké (Transcaucasie): Comptes rendus de l'Acad. des Sci., 22 février 1904. Cet auteur leur écrit encore: "Peut-être y aurait-il lieu d'appliquer l'étude des hélices d'avant, et celle de la marche des rivières souterraines à la controverse toujours pendante sur la prétendue loi de Baer (déviation des rivières sur la droite), comme viennent de le faire très judicieusement MM. B. et J. Brunhes pour les tourbillons de l'atmosphère et des cours d'eau." Et il ajoute avec grande raison: "Mais cette application serait très délicate à cause de l'action perturbatrice des fissures et des pendages sur la marche normale des courants souterrains."

seulement noter ici,[a] nous avons, un de mes frères et moi, proposé cette interprétation, nous avons indiqué les analogies entre les tourbillons de l'air et de l'eau; nous avons surtout rappelé la curieuse expérience trop oubliée, présentée par Perrot à l'Académie des Sciences en 1859 Nouvelle expérience pour rendre manifeste le mouvement de la terre.[b]

Mon frère, M. Bernard Brunhes, directeur de l'Observatoire du Puy-de-Dôme, a depuis lors tout spécialement montré comment il était naturel que la force centrifuge composée provenant de la rotation terrestre pût déterminer le sens de rotation; il a insisté sur cette considération que le sens de rotation dépend uniquement du rapport entre la durée de rotation du tourbillon de l'air ou de l'eau et la durée de la rotation terrestre. Le calcul l'a conduit à penser que sur tous les tourbillons ayant au moins une seconde comme durée de rotation l'influence de la rotation terrestre pourrait s'exercer efficacement.[c]

Cependant l'interprétation ne saurait avoir la même certitude que le fait observé; et même si des observations poursuivies, comme nous le souhaitons et le demandons, dans l'hémisphère austral, rendaient un jour caduc notre essai d'explication, le fait observé, c'est-à-dire la prédominance générale des tourbillons *sinistrorsum*, dans les cours d'eau de l'Europe centrale et occidentale n'en resterait pas moins réel. Encore convient-il d'exposer très nettement et d'une manière critique les conditions générales de ces phénomènes de vorticologie, ainsi que leurs conditions-limites au point de vue géographique.

Il est très important d'observer ce que deviennent les tourbillons d'un même rapide au fur et à mesure que les eaux montent dans un cours d'eau. J'ai mis en observation, à cette fin spéciale, un tout petit rapide de la Sarine de 35 mètres de longueur, qui se trouve immédiatement en aval du rapide signalé plus haut sous le No. 1 et situé exactement à la tête du grand méandre de la Maigrauge.

Plus les eaux sont basses plus les tourbillons sont nombreux, car les pierres qui encombrent le lit apparaissent plus nombreuses à la surface ou près de la surface. Quand les eaux montent, les tourbillons apparents à la surface, c'est-à-dire se traduisant par des lignes d'écume, tendent à se réduire en nombre; mais les principaux d'entre eux se manifestent avec plus de violence et plus de netteté.

Dès que le niveau général de l'eau est en effet à 1 mètre environ au-dessus du fond, les irrégularités du fond ne produisent plus d'accidents secondaires jusqu'au niveau supérieur, et les seuls tourbillons qui subsistent non seulement sont plus considérables, mais —fait capital—

[a] Brunhes, Bernard, et Brunhes, Jean, Les analogies des tourbillons atmosphériques et des tourbillons des cours d'eau, et la question de la déviation des rivières vers la droite: Annales de Géographie, XIII, 1904, pp. 1-20.

[b] Comptes rendus de l'Acad. des Sci., XLIX, 1859, p. 637; voir aussi Bernard Brunhes, Sur une expérience de Perrot et sur la comparaison directe de la rotation terrestre et du champ magnétique terrestre: Société météorologique de France, séance du 6 avril 1904.

[c] Annales de géographie, loc. cit., pp. 14-16, et Comptes rendus de l'Acad. des Sci., juin 1904.

tournent en plus forte proportion dans le sens inverse des aiguilles d'une montre.

Je reproduis ici deux des observations faites sur le rapide en question, et je choisis deux moments assez caractéristiques.

A. Petit rapide de la Sarine de 35 mètres de longueur, à la tête du grand méandre de la Maigrauge—14 mai 1904, eaux moyennes. Outre les tourbillons produits en aval des pierres qui dépassent (deux notamment produisant chacune deux tourbillons dans chaque sens) et outre trois tourbillons à sens indéterminable, on compte douze tourbillons simples, dont un seul *dextrorsum* et douze complexes tourbillonnaires, tous *sinistrorsum;* en tout, sur vingt-quatre faits tourbillonnaires il y en a vingt-trois en sens inverse des aiguilles d'une montre (soit 95.8 pour cent) et un seul dans l'autre sens.

B. Même rapide de la Sarine, observé un mois plus tard, le 14 juin 1904, les eaux étant sensiblement plus hautes. Outre les deux groupes de tourbillons qui se produisent en aval des deux blocs dépassent encore le niveau de l'eau, je ne compte plus qu'un tourbillon à sens indéterminable et vingt-et-un tourbillons ou complexes tourbillonnaires observables, et tournant tous dans le sens inverse des aiguilles d'une montre.

Il semble bien que plus les eaux sont indépendantes du fond, plus la rotation en sens inverse des aiguilles d'une montre devient prédominante.

Ce sont là, toutefois, dans les deux cas A et B des termes moyens. Il s'agit encore de savoir ce que deviennent les tourbillons d'un même rapide tel que celui-là: 1° lorsque les eaux deviennent trés basses, et 2° lorsque les eaux deviennent très hautes; et par l'examen d'un cas précis nous aborderons mieux la partie critique de cette étude—partie indispensable qui doit préciser en quels cas, et en quels cas exclusivement peut se manifester la prédominance des tourbillons *sinistrorsum*.

1° Lorsque la Sarine devient tout-à-fait basse—prenons par exemple le mois d'août 1904, et, si l'on veut, les observations du 10 et 11 août — les blocs et les pierres qui revêtent tout le lit apparaissent si bien audessus des eaux que tous les tourbillons appartiennent à cette catégorie spéciale que nous avons éliminée par principe de nos tableaux statistiques et que nous pourrions appeler "les tourbillons de l'aval d'une pile de pont."

Ce que nous disons de la Sarine s'applique, on le conçoit, à toutes les rivières obstruées de gros matériaux, et notamment à tous les tronçons supérieurs des cours d'eau alpins. J'ai par exemple observé la Reuss entre le Pont du Diable et Göschenen le 24 février 1904: la Reuss était très basse, et les parties secondaires de son lit habituel étaient sans doute glacées ou même abandonnées par les eaux, en tous cas recouvertes d'une couche de neige; le petit lit principal n'était plus qu'une suite de petits rapides encombrés de pierres dont un très

grand nombre dépassait le niveau des eaux. Il ne pouvait donc y avoir là rien de caractéristique à étudier.

2°. Quand la Sarine devient très haute, aussi haute qu'elle l'a été lors de la grande crue de 1888, quand à l'endroit du petit rapide considéré elle a 2 à 4 mètres de profondeur (ce qui est anormal et très rare), on imagine aisément par beaucoup d'autres exemples de rapides de cours d'eau ayant cette profondeur ce qui se produit à la surface: des ridements d'écume ressemblant à des feux follets parsèment à peine la nappe liquide, ou même le flot roule violent sans aucune crête d'écume. Ce n'est pas que les tourbillons soient absents; bien au contraire, il se peut qu'ils se produisent en profondeur plus nombreux et plus puissants que jamais. Mais ils perdent pour ainsi dire toute personalité superficielle; ils sont "noyés" dans le flot avant d'arriver jusqu'à la partie supérieure, et l'observateur ne peut plus rien découvrir en ce qui concerne leur nombre, leur place exacte, et a fortiori leur sens de rotation.

Ainsi il y a deux extrêmes dans le régime d'un cours d'eau—extrême de faiblesse et extrême de force—pour lesquels l'observation des tourbillons ne présente plus aucun intérêt ou devient même impossible et nulle. C'est entre ces deux extrêmes que doivent être compris tous les rapides des cours d'eau qui sont susceptibles de fournir à l'observateur des informations précises sur le sens de rotation. C'est dire que le nombre des points observables et des portions de cours révélatrices est relativement très faible. Partout où un cours d'eau roule trop directement sur les pierres, et partout où un cours d'eau roule un flot trop abondant sur une épaisseur telle que les manifestations superficielles des phenomènes tourbillonnaires soient fatalement amorties ou même supprimées, nous ne pourrons rien observer qui nous renseigne sur le problème qui nous occupe.

En vertu même des caractères essentiels des faits à observer, tous les torrents et toutes les grosses rivières, toutes les parties de torrents et toutes les parties de rivières ou de fleuves qui correspondent aux deux cas signalés—et c'est de beaucoup la grande majorité—doivent à ce point de vue particulier être considérés "comme nuls et non avenus."

L'examen critique des cas observables exige encore l'élimination de deux autres séries de cas, lesquelles d'ailleurs coïncident parfois, quoique rarement, avec les précédentes. Lorsque le flot est trop resserré ou lorsque la pente est trop raide, les eaux s'engouffrent ou se précipitent, et produisent, dans une circonstance comme dans l'autre, un nombre incalculable et une multitude souvent indiscernable de tourbillons. Dans le cas du reserrement les tourbillons se mêlent, se heurtent, se contredisent, et finalement se traduisent à la surface par des masses continues d'écume bouillonnante, le plus fréquemment si confuses qu'il est impossible de distinguer les divers tourbillons et de

reconnaître leur sens de rotation. Tel est le spectacle que nous offrent ces goulets étroits que nous avons appelés des "gorges à marmites," et dont les parois représentent avec le plus de fraîcheur et le plus d'authenticité la tactique de l'érosion tourbillonnaire: gorge de l'Aar ou gorge de la Tamina,[a] gorge du Für ou Liechtensteinklamm, etc. Certes les tourbillons sont là multiples et tout-puissants, mais ils échappent à toute nette observation. Que l'on examine également au Pont des Oulles le chenal principal où s'engouffre la Valserine; que l'on examine encore comme je l'ai fait le 19 février 1904, la gorge de la Reka dans les célèbres grottes de Saint-Cassian (Karst), on aperçoit bien ça et là quelques tourbillons individualisés, et il semble même qu'il y ait peut-être prédominance de tourbillons *sinistrorsum;* mais vouloir faire une statistique serait une pure illusion: les flots se contredisent si bien que la surface est souvent ridée de vagues qui n'ont aucun rapport avec les mouvements profonds. Dans d'autres gorges ou portions de gorges un peu moins droites, notamment dans les petits fiefs de la gorge de Piottino (qui est une gorge à marmites creusée dans les schistes cristallins), on constate un bouillonnement de surface sans beaucoup d'écume qui ressemble tout-à-fait au bouillonnement d'un liquide en ébullition; les tourbillons viennent ainsi "crever" à la surface, mais d'une manière telle qu'il est à peu près impossible de savoir en quel sens ils tournent.

Bien plus, nous croyons pouvoir induire de l'ensemble de nos observations sur les tourbillons des gorges que s'il était possible d'établir des statistiques analogues à celles que nous avons plus haut dressées, on ne trouverait sans doute plus cette forte et remarquable prédominance d'un sens de rotation.

Dans le cas de la descente très rapide des eaux, les observations précises sont encore malaisées et nécessairement trop fragmentaires; du moins elles sont par endroits possibles, et en voici un exemple:

Avec un de mes élèves,[b] j'ai essayé de compter les tourbillons *sinistrorsum* et *dextrorsum* qui se produisent dans le cours tout-à-fait supérieur de la Lütschine, ou plus exactement de l'une de ces têtes de la Lütschine qui sortent du glacier inférieur de Grindelwald;[c] dans la gorge à marmites qui fait suite à l'extrémité du glacier, tout discernement est matériellement impossible. Nos observations ont commencé aux gros blocs qui ferment la gorge proprement dite, un peu en amont du petit pont qui conduit aux passerelles de la gorge, et elles ont porté

[a] Voir notre mémoire déjà cité: Le travail des eaux courantes, la tactique des tourbillons: Mém. Soc. frib. des sc. nat., p. 2; voir aussi Nouvelles observations sur le rôle et l'action des tourbillons, Le Globe, Mémoires, p. —.

[b] C'était Monsieur le docteur Hannsen qui m'accompagnait ce jour-là, le 4 août 1904. Je me suis arrangé autant que possible pour faire toujours ces observations délicates avec un témoin qui m'aidât à discerner le sens de rotation, et qui constituât pour moi-même un contrôle. Un autre de mes élèves, Monsieur Cesare Calciati, m'a aidé pour certaines des observations signalées dans ce mémoire.

[c] Les têtes de la Schwarze Lütschine s'appellent Weisse Lütschinen (Atlas Siegfried, feuille 396, Grindelwald, à 1:50,000); elles portent donc le même nom que l'autre Lütschine, la Lütschine blanche (Lütschine de Lauterbrunnen) qui rejoint la Lütschine noire à Zweilütschinen.

sur 400 mètres. Elles ont été très pénibles. Les eaux étaient fortes et les mouvements tourbillonnaires formaient une suite presque ininterrompue. Nous n'avons noté que ceux qui étaient assez individualisés pour qu'on pût en reconnaître le sens de rotation.

Du tableau que nous avons obtenu, je détache les résultats: sur quarante-cinq tourbillons, vingt étaient *sinistrorsum* et vingt-cinq *dextrorsum*, et sur huit complexes tourbillonnaires, six étaient *sinistrorsum* et deux *dextrorsum;* au total, vingt-six tournaient dans le sens inverse des aiguilles d'une montre et vingt-sept dans le même sens que les aiguilles d'une montre.

Parité presque parfaite entre les tourbillons d'un sens et les tourbillons de l'autre sens, on saisit tout de suite combien ce rapide est différent des rapides à tourbillons dénombrés ci-dessus. Il me reste à indiquer maintenant pour quelles raisons rien n'est plus logique que cette différence.

De la gorge de la Lütschine jusqu'à Gsteig le cours d'eau, sur un parcours de 18 kilomètres, descend de 400 mètres (il passe de la côte 990 à la côte 590), ce qui donne une pente moyenne de 22 mètres par kilomètre.

Une pente pareille fait que la pesanteur joue un rôle capital dans l'entraînement des eaux; les eaux qui vont tourbillonner tombent d'une manière telle que ce sont avant tout les conditions de cette chute qui déterminent le sens de la rotation tourbillonnaire; il se produit là en petit mais très multiplié un phénomène comparable en somme à celui des "Calderoni" ou "Chaudrons" du Brenton, décrits par S. Squinabol.

S'il est admissible, comme nous l'avons indiqué, que dans le cas de rapides à dénivellations moins fortes, ce soit la rotation terrestre qui explique la prédominance des tourbillons en sens inverse des aiguilles d'une montre, il est également admissible, bien plus il est nécessaire, que lorsque l'une des forces qui est à l'origine du mouvement tourbillonnaire atteint une certaine intensité, la force représentée par la rotation terrestre devienne si insignifiante qu'elle n'ait plus une action décisive et manifestée.

Ainsi tous les rapides violents, soit trop resserrés, soit trop raides, doivent être encore éliminés de la catégorie de ceux qui se prêtent à l'observation.

Une conclusion qui a son importance se dégage de ce qui précède: là où les tourbillons sont le plus actifs et le plus puissants; là où ils opèrent leur plus gros travail, il semble qu'ils doivent être en nombre à peu près égal *sinistrorsum* ou *dextrorsum*, ou plutôt il apparaît qu'il n'y a plus de raison pour qu'un sens prédomine de beaucoup sur l'autre.[a] Ils représentent de telles forces et ils sont déterminés par

[a] Notons pourtant que parmi les marmites que nous avons étudiées en si grand nombre et qui, pour une bonne part, ont été sans aucun doute élaborées sur l'emplacement des rapides violents, les sillons hélicoïdaux en sens inverse des aiguilles d'une montre nous semblent bien, là encore, et dans l'ensemble, légèrement prédominer.

des facteurs si énergiques qu'ils échappent à toute influence indirecte— l'influence de la rotation terrestre est relativement très faible et se trouve maintes fois annihilée.

On comprend dès lors ce que nous voulions indiquer dans notre note du 11 avril 1904 que "les rapides qui se prêtent à l'observation ne sont ni les rapides trop profonds, ni les rapides trop violents." Et l'on comprend aussi pourquoi des observations non sériées et classées avaient pu faire croire qu'il n'y avait pas dans les tourbillons des cours d'eau de sens prédominant. D'abord, le spectacle symétrique que présentent les tourbillons en aval des piles d'un pont, spectacle qui est le plus communément observé par tous les habitants des villes, était bien fait pour fausser les idées; et puis, on le voit, des groupes déterminés de rapides ne présentent pas et ne peuvent pas présenter cette éclatante prédominance.

C'est en fin de compte dans les parties moyennes des cours d'eau que nous aurons le plus de chances de trouver ces rapides à pente sensible mais assez modérée, sur les tourbillons desquels ils est permis de supposer que la force centrifuge composée exerce une influence de direction.

Sera-t-il possible de préciser plus tard entre quelles limites exactes peuvent varier: 1° les pentes, et 2° les profondeurs de tels rapides marquant la prédominance du sens de rotation *sinistrorsum* des tourbillons?

Sera-t-il possible de caractériser et de définir cette catégorie de rapides à laquelle appartiennent tous les rapides que nous avons signalés dans la première partie de cet article? C'est là l'objet présent de nos recherches.

Dès aujourd'hui il nous est toutefois possible de les localiser dans les parties moyennes des cours d'eau, car dans les parties supérieures les pentes sont trop rapides, non seulement pour que l'observation soit possible, mais sans doute aussi pour qu'une forte prédominance d'un sens de rotation se manifeste; et dans les parties inférieures de nos cours d'eau alpins ou pyrénéens la pente est si faible et la masse des eaux est si considérable que non seulement la surface de l'eau ne porte aucune ride d'écume, aucun signe révélateur, mais que sans doute aussi les tourbillons en profondeur diminuent en nombre et en activité.

Reprenons enfin les conclusions de cet autre mémoire,[a] dans lequel nous avons tenté d'expliquer partiellement la déviation des rivières vers la droite par l'action des tourbillons et par la prédominance des tourbillons *sinistrorsum*. Cette interprétation de la loi dite de Baer comportait, comme caractère essentiel, une limitation des faits groupés sous cette loi à certaines portions et à certaines portions seules des cours d'eau.

[a] Brunhes, B. et J., Les analogies des tourbillons atmosphériques et des tourbillons des cours d'eau et la question de la déviation des rivières vers la droite.

"Quant à la loi de Baer elle-même, écrivions-nous, mérite-t-elle le nom de loi?" Mérite-t-elle au moins le nom de règle que proposait en 1865 Schweinfurth?[a] Il y a sans doute un certain nombre de faits hydrographiques qui portent la marque de la rotation de la terre. Mais ces faits sont limités à certaines portions de fleuves: 1°. Ils ne se rencontrent, nous l'avons dit, ni dans les zones montagneuses des bassins hydrographiques, où les eaux tombent plutôt qu'elles ne coulent, ni dans les zones inférieures de remblaiement telles que les deltas; ils ne se rencontrent que dans les parties moyennes où le cours d'eau est encore en travail; 2°, dans tous les tronçons de ces parties moyennes elles-mêmes où l'écoulement des eaux est dirigé par une cause prépondérante: pesanteur, dont l'intensité croit avec la pente; vents, dont l'action est en rapport avec l'orientation, etc., tous les autres facteurs, et en particulier le facteur de la rotation terrestre, ont une influence soit supplémentaire et imperceptible, soit contradictoire, mais minuscule, et de fait contredite.[b]

"Si la rotation terrestre agit en vérité, l'action n'en peut être traduite que par des effets de second ordre. Qui ne méconnaît ni la nature même de cette cause spéciale, ni la réalité géographique des multiples autres causes—tectoniques, topographiques et climatiques—doit être surpris, non plus de la relative rareté, mais au contraire de la relative généralité, de l'importance et du grand nombre des faits qui manifestent l'inégale attaque des deux rives d'un cours d'eau: 'guirlandes' à concavité sur la droite (Danube ou Rhin), surélévation presque continue de la rive droite de longs fleuves (Volga ou Dniepr), etc.

"Or ces faits correspondent à des chenaux d'écoulement, où les eaux, échappant à la souveraineté exclusive de toute autre influence, sont en état de subir et de marquer l'influence assez faible, mais continue, incessante, qui résulte de la rotation de la terre. Comment se traduit cette action? Non seulement les filets d'eau tendent à glisser avec plus de vitesse et plus de force vers la rive droite (Baines, Günther), mais encore tous les mouvements tourbillonnaires hésitants sont déclanchés dans le sens inverse des aiguilles d'une montre.

"Si la loi de Baer, sous sa forme absolue et exagérée, doit être rejetée, il n'en semble pas moins vrai que dans la géographie des cours

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[a] Schweinfurth, G., Der Nil und das Baer'sche Gesetz der Uferbildung: Petermanns Mitt., XI, 1865, p. 126.

[b] Voilà comment nous admettons avec Mons. L.-A. Fabre (La dissymétrie des vallées et la loi dite de Baer, particulièrement en Gascogne, dans La Géographie, VIII, 1903), que beaucoup de cas de dérivation des thalwegs (vallées du Lannemezan, Rhône, etc.) s'expliquent par des facteurs géographiques locaux: vents, pente, charriage des affluents, etc.; voilà comment nous approuvons l'esprit de véritable observation qui se traduit par une phrase comme celle-ci: "Si le Mississippi se montre récalcitrant à la loi de Baer, il se conforme sans doute, comme la plupart de ses pareils, à d'autres lois moins abstraites et plus naturelles," p. 314. Et pourtant nous estimons que dans la conclusion suivante le mot unique dépasse les prémisses: "Cet exposé sommaire des cas les plus intéressants de vallées dissymétriques et de dérivations fluviales établit que le double phénomène est sous la dépendance unique de causes géologiques et géographiques," p. 315.

d'eau toute une catégorie de faits disséminés, mais exactement localisés et similaires, peuvent être légitimement attribués au mouvement quotidien de la terre sur elle-même."[a]

Qui ne voit la parfaite concordance entre ces portions des cours d'eau où se revèlent les marques d'une dissymétrie et d'une déviation des rivières vers la droite, et ces portions des cours d'eau où se rencontrent les rapides manifestant une prédominance incontestable du sens de rotation des tourbillons en sens inverse des aiguilles d'une montre?

Nos connaissances générales sur l'écoulement des liquides dans la nature sont encore très incomplètes. Nos études personnelles de vorticologie sont encore bien loin d'être achevées. Mais il y a déjà là un fait de concordance qui nous a paru digne d'être signalé et interprété.

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[a] Annales de Géographie, Vol. XIII, 1904, pp. 19-20.

RAINFALL WITH ALTITUDE IN ENGLAND AND WALES

By WILLIAM MARRIOTT, F. R. Met. Soc.

It is a recognized fact that mountainous districts have a heavier rainfall than lowland districts and that the amount of rainfall increases in some measure with increased altitude above sea level. An opportunity occurred some time ago of putting this to a practical test in the case of England and Wales.

In 1897 a volume of Rainfall Tables of the British Islands, 1866–1890, was issued by the meteorological office, London, in which the information had been supplied chiefly by the late Mr. G. J. Symons, F. R. S. Part 3 of the volume contained an abstract of the mean monthly and annual rainfall for the ten years, 1881–1890, at 492 stations. This is a very valuable table, as it permits a strict comparison to be made of the rainfall at all those places for the same period.

By extracting the mean annual rainfall at all the stations in England and Wales—viz, 311—and grouping them according to their altitude above sea level, the writer found the results to be as follows:

Altitude.	No. of stations.	Rainfall.	Altitude.	No. of stations.	Rainfall.
		Inches.			*Inches.*
1–50 feet	47	27.23	401–450 feet	11	43.29
51–100 feet	37	28.27	451–500 feet	16	38.83
101–150 feet	39	29.71	501–600 feet	16	37.88
151–200 feet	35	81.25	601–700 feet	8	39.01
201–250 feet	25	29.60	701–800 feet	8	53.69
251–300 feet	23	83.55	801–900 feet	2	55.01
301–350 feet	23	33.29	901–1,000 feet	4	56.99
351–400 feet	10	30.66	Above 1,000 feet	7	69.10

The above figures show very clearly that there is an increase of rainfall according to altitude above sea level.

The prevailing winds over the British Islands are southwesterly. These come from the Atlantic as moist winds, and as they strike the land they are forced upward and, owing to the consequent reduction of temperature, have to part with some of their moisture in the form of rain, and so the rainfall in the west is greater than in the east. The greater the velocity of the wind the more rapid is the condensa-

tion of the moisture, and consequently the heavier the rainfall. When the current of air has passed over the high ground, it descends on the east side of the range a drier air, as it has parted with a great deal of its moisture, and consequently the conditions are not so favorable for the formation of rain over the eastern as over the western districts.

In order to bring this out clearly the writer separated the western from the eastern stations, considering all stations as "western" which drained to the west and all stations as "eastern" which drained to the east. There were in all 149 western stations and 162 eastern stations. The mean annual rainfall at the various altitudes was as follows:

Altitude.	West.		East.		Altitude.	West.		East.	
	No. of stations.	Rainfall.	No. of stations.	Rainfall.		No. of stations.	Rainfall.	No. of stations.	Rainfall.
		Inches.		*Inches.*			*Inches.*		*Inches.*
1-50 feet	16	32.79	31	24.36	401-450 feet	6	56.26	5	27.73
51-100 feet	13	33.59	24	25.39	451-500 feet	12	41.00	4	32.54
101-150 feet	16	35.40	23	25.76	501-600 feet	11	38.08	5	35.84
151-200 feet	18	36.28	17	26.14	601-700 feet	5	41.25	3	35.27
201-250 feet	8	36.50	17	26.35	701-800 feet	5	58.83	3	45.12
251-300 feet	17	35.36	6	28.41	801-900 feet	2	55.01	0	....
301-350 feet	9	41.05	14	28.30	901-1,000 feet	3	59.54	1	49.33
351-400 feet	3	35.10	7	28.75	Above 1,000 feet	5	79.03	2	44.27

It is at once apparent from the above figures that there is a greater rainfall in the west than in the east. Unfortunately, the number of stations for the higher altitudes is very small; otherwise the results would probably be much more uniform than those given above.

The writer also treated in the same manner the mean monthly rainfall at 309 stations by separating them into "western" and "eastern" stations and grouping them according to altitude. The results are given in the following table:

Mean monthly rainfall, 1881-1890, grouped according to altitude for west and east.

WEST.

Altitude.	No. of stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1-50 feet	16	2.81	2.14	2.35	*1.93*	2.19	2.19	3.07	2.84	2.93	3.41	**3.89**	3.04
51-100 feet	13	2.97	2.45	2.35	*2.03*	2.19	2.16	3.10	2.67	2.91	3.52	**4.04**	3.20
101-150 feet	16	3.10	2.45	2.64	*2.10*	2.45	2.23	3.46	3.08	3.15	3.47	**4.08**	3.24
151-200 feet	18	3.29	2.64	2.59	*2.19*	2.41	2.33	3.49	2.89	3.16	3.67	**4.29**	3.33
201-250 feet	8	3.37	2.86	2.73	*2.38*	2.44	2.42	3.22	2.66	2.89	3.69	**4.33**	3.53
251-300 feet	17	3.16	2.63	2.58	*2.18*	2.44	2.40	3.19	2.80	3.06	3.64	**4.11**	3.21
301-350 feet	9	3.66	3.05	3.01	*2.39*	2.67	2.65	3.70	3.21	3.58	4.40	**4.68**	4.05
351-400 feet	3	3.00	2.43	2.52	*2.27*	2.49	2.66	3.56	3.10	3.03	3.27	**3.77**	3.00
401-450 feet	6	5.81	4.60	4.40	3.13	3.69	*3.11*	4.94	4.29	4.67	5.33	**6.68**	5.58
451-500 feet	12	3.70	3.20	2.95	*2.61*	2.81	2.63	3.59	3.25	3.44	4.13	**4.33**	3.85
501-600 feet	11	3.48	2.88	2.82	*2.28*	2.58	2.44	3.40	3.16	3.03	3.94	**4.44**	3.66
601-700 feet	5	3.75	3.28	3.01	*2.51*	2.70	2.53	3.47	3.42	3.25	4.43	**5.02**	3.89
701-800 feet	5	5.55	4.33	4.43	*3.27*	3.51	3.53	5.38	4.93	5.25	5.91	**6.90**	5.85
801-900 feet	2	5.56	4.10	4.31	3.32	3.55	*3.21*	4.65	4.19	4.22	5.68	**7.01**	5.21
901-1,000 feet	3	6.16	4.87	4.42	3.41	3.76	*3.07*	4.71	4.81	4.82	6.08	**7.38**	6.06
Above 1,000 feet	3	4.03	3.06	3.04	*2.69*	2.99	3.10	4.02	3.98	3.87	5.11	**5.18**	4.45

The black-faced figures indicate the greatest monthly rainfall. The italic figures indicate the least monthly rainfall.

Mean monthly rainfall, 1881–1890, grouped according to altitude for west and east—Cont'd.

EAST.

Altitude.	No. of stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1-50 feet	31	1.78	*1.57*	1.66	1.59	1.83	1.68	2.47	2.07	2.29	**2.89**	2.53	2.00
51-100 feet	24	1.94	*1.65*	1.81	1.69	1.94	1.77	2.54	2.15	2.30	**2.94**	2.59	2.09
101-150 feet	23	1.91	*1.71*	1.84	1.75	1.97	1.82	2.62	2.21	2.32	**2.87**	2.67	2.07
151-200 feet	17	2.04	*1.75*	1.88	1.78	2.00	1.84	2.59	2.21	2.29	**2.85**	2.80	2.12
201-250 feet	17	1.92	1.78	1.91	*1.76*	2.10	1.92	2.67	2.30	2.35	**2.83**	2.74	2.05
251-300 feet	6	2.01	*1.81*	2.18	1.83	2.14	1.88	2.77	2.53	2.59	3.15	**3.17**	2.35
301-350 feet	14	2.28	1.96	2.08	*1.88*	2.17	2.06	2.76	2.31	2.46	2.94	**3.05**	2.35
351-400 feet	7	2.25	*1.94*	2.15	2.04	2.09	1.99	2.98	2.40	2.47	**3.17**	3.02	2.26
401-450 feet	5	2.26	*1.90*	1.98	2.03	2.20	1.99	2.73	2.26	2.32	2.84	**3.08**	2.20
451-500 feet	4	2.77	2.25	2.51	*2.01*	2.26	2.31	3.12	2.92	2.67	3.25	**3.48**	2.79
501-600 feet	5	2.81	*2.17*	2.93	2.21	2.52	2.48	3.62	3.32	3.28	3.70	**3.72**	3.09
601-700 feet	3	3.16	2.32	2.60	*2.04*	2.24	2.34	3.18	3.07	3.25	**3.96**	3.93	3.19
701-800 feet	3	4.47	3.16	3.67	2.66	2.74	*2.52*	4.25	3.78	3.77	4.72	**5.16**	4.21
801-900 feet	0	......	......	......	......	......	......	......	......	......	......	......	......
901-1,000 feet	1	4.65	3.52	3.96	*2.47*	3.24	3.25	4.43	4.26	3.83	5.23	**5.70**	4.79
Above 1,000 feet	2	4.09	*2.87*	3.43	2.95	3.25	2.86	3.94	3.30	3.31	**5.48**	4.88	3.90

The black-faced figures indicate the greatest monthly rainfall. The italic figures indicate the least monthly rainfall.

The above values bring out the following features:

1. The monthly rainfall in the west is subject to a much greater range than in the east.

2. In the west the maximum at all altitudes occurred in November, but in the east generally in October.

3. In the west the spring months, April, May, and June, are very dry.

4. There is a great increase in the rainfall from June to July both in the west and in the east.

In the spring months there is a great prevalence of northeast winds. These, as a rule, are drier than the south-west winds, as they are often associated with anticyclonic conditions. There is no doubt that the heavy rainfall in July is due in large measure to the prevalence of thunderstorms. The isobaric and wind charts show that the prevailing winds for July are decidedly westerly; whereas in the spring months the prevailing winds are light and more from the north.

The data dealt with in this paper apply only to the ten years 1881–1890; if the period had been much longer, the results might perhaps have been somewhat modified, and they certainly would have been more uniform.

It must be borne in mind that the information given in this paper applies only to the west and east of England and Wales and not to individual stations. The exposure, position, and surroundings, as well as the altitude, affect the rainfall; so each individual case must be judged on its own merits.

CLIMATOLOGY OF THE LOWLANDS AND WATERSHED TERRACES OF NATAL

By FREDERICK W. D'EVELYN, M. B., C. M., San Francisco, Cal.

To the adventurous navigator or intrepid explorer what more supreme moment could there be than that when he stands, the discoverer—the first white man to view an unknown land rising upon the horizon; or when, having overcome many dangers and endured hardships, he pierces the veil of mystery and sees a territory, hitherto incognita, expand in ever freshening novelty before his wondering eyes? Such a moment as this must that sturdy old Portuguese commander, Vasco de Gama, have experienced when, as he tells us, "having rounded Cabo Tormentosa, and his ships feeling their way along the unknown eastern coast of the African continent, amidst the gray dawn of Christmas morning, he came upon a 'bold headland,' with an inlet of sheltered water behind." There he struck sail and anchored his ocean-tossed ships.

In honor of the auspicious day and in response to the feeling of his thankful heart he named it "Terra Natalis"—the land of the nativity. The old name has tenaciously clung to the soil, and to this day the colony is known as Natal. On the low sand spit, probably where he first landed, the colonists have erected a monumental fountain surmounted by a clock. The "bold headland" which he first sighted is the sea terminal of a rocky spur of the coast line, 211 feet in elevation, and is now surmounted by a light-house 80 feet high, whose brilliant eye throws its warning rays a distance of 24 miles across the uncertain waters of the Indian Ocean.

A bird's-eye view of the colony, taken at a proper elevation from this very spot, would show that this segment of the outer rim of the continent has a formation which is unique in its physiography, and which, it is justifiable to conclude, influences in an essential manner the organization and vitality of that entire area, extending from this coast line to its northern limit, the watershed of the Zambesi. Most certainly, it is the principal initiatory factor in the immediately localized climatic conditions. Just in measure as we appreciate these

essentials will our knowledge of the vagaries of the climate be instructive and trustworthy.

These statements are to be understood as referring to the old colony—that great rock wedge driven obtrusively into the sandy undulating coast line which stretches for many miles north and south.

The base or sea line of this wedge extends from the small Umtamvuma River, 31° 10′ south, to the mouth of famous Tugela River, 29° 10′ south, a distance of 150 miles; the apex of the wedge runs northward 220 miles, reaching the berg, where it represents an elevation of 2¼ miles. This elevation is attained by a series of terraces. The first extends inland from the sea a distance of 14 miles and attains an elevation of 1,000 feet; this is followed by a plateau, which is about 20 miles in width at a distance of 34 miles from the sea and has an altitude of 2,500 feet; the next terrace, a few miles broader, rises to an elevation of 3,700 feet, and is followed by a similar one, which reaches a level of 5,000 feet.

The last terrace in the series rises to an elevation of 6,000 feet and becomes the floor space upon which are borne the great peaks of the Drakensberg. The proximity of this mountain range has a distinct influence upon the area that constitutes the apex of the wedge, which, though several hundred miles nearer the Tropics, is not correspondingly hotter, owing to the marked elevation of this great inland frontier.

The term range is more popular than scientific or correct, for actual examination shows that the "range" is really the broken edge of what appears to be a great continental plateau. I can readily recall how markedly this deduction was forced upon me, when, after a circuitous journey of some 5 miles, over rocky terraces and bowlder-strewn paths, I reached the top of the range at an elevation of 5,500 feet. Having done so, I naturally expected to find upon the other side a descent somewhat proportionate to the ascent just made; but no; the landscape was simply a broad, undulating prairie, lost in the far-distant hazy outline, over which swept the winds, born not of the sun-warmed terraces of Natal, but the offspring of the rugged and often snow-clad peaks of the Dragon's Mountain.

In this region this edge or rim practically forms the boundary of Natal, giving to the colony one of its peculiarities, already referred to.

Leaving Natal, the edge loses much of its rocky character, sinks almost to the plain level, and ceases to run so closely parallel to the coast line. This deflection deprives the adjacent area of that vagary of climate which is so marked in the apex region.

In its further course the "edge" trends still more inland, much modified in its character, ultimately turning sharply westward, constituting in so doing the southern watershed of the Zambesi.

It must be noted that the range, while still forming the boundary of Natal, gives off a series of spurs of varying elevation and length. As

a result the rocky plateaus are subdivided into climatic areas and watersheds for the smaller river systems and the innumerable streams, which not alone modify the topography but constitute channels of irrigation, thereby maintaining that persistent verdure and productiveness which has won for Natal the title "the colony of garden and meadow land."[3]

The caprices of these formations are in sections so obtrusively thrust upon the traveler that he is oftentimes reminded of the great forces which had been employed in producing such bewildering landscapes; the igneous understructures are torn and rent; aqueous and metamorphic rocks intrude in odd ways and in unexpected places.

Huge, detached bowlders, suspended, as it were, in midair, oftentimes hang threateningly from the hillsides which flank the pathways along which he is traveling.

Numerous indeed are the instances where some gigantic "outlier," in obtruding its presence, has uplifted the superimposed strata of sandstone for many feet into the air, often in immense areas; thus are formed the "table-top hills" which are such characteristic features in the landscape of the midland and highland regions of the colony.

It is a self-evident sequence that such a variation of contour, crowded into an area of comparative limitation, should exercise special influences over local climatic conditions, and when with this great land factor we conjoin a great sea factor, we are prepared for the demonstration of many important and interesting atmospheric phenomena.

It is worthy of recall that some of these very phenomena, bearing in a measure upon the region under our consideration, were first noted by the sailors of the early Portuguese navigators, who as they traversed these latitudes observed with much wonder and not a little superstition the constancy of the winds ever blowing them, as they said, "toward some gulf, situated at the limits of an unknown world." Commerce, recognizing the value of these air currents, has long since baptized them "trade winds."

Natal is not in the exact latitude of the southeast trade wind, but sufficiently so to be influenced in a measure by its proximity. Further, the peculiar formation and trend of the superficies and coast line of the colony obtain for it advantages which almost compensate for less close relationship.

The southern trade wind has for its birthplace the immense basin of the Indian Ocean, the superficial evaporation of which is more active than that of all the other seas of the world. The air, as it is forced upward and onward by constant radiation, absorbs from this source an ever-increasing burden of aqueous vapor. As it approaches the latitude of Natal it encounters the local sea breeze, a current resulting from a combination of factors already casually referred to, viz, the general land trend of the colony toward the northwest, its physiog-

raphy, and its heat radiation. Owing to the fact that the land during the hot season absorbs a relatively larger amount of heat than the adjacent sea, an indraft or suction is produced, drifting landward, which diverts in a measure the trade wind flowing in a similar direction. Thus is produced a combined aerial current, which as it strikes the coast line at once encounters the ascending rocky terraces already described, veritable gigantic inclined planes, forcing it to ever higher levels.

As it ascends pressure is reduced, expansion takes place, latent heat is lost. Its carrying power steadily decreases; it falters upon the hill tops, draping them in fog and cloud, while its burden of aqueous vapor falls as abundant rains.

So uniform in operation are these climatic factors that we find the seasons practically divided into a wet or summer season, October to April, and a dry or winter season, occupying the remaining months. The sea breeze is much less prevalent in the winter months, and the evaporation from the ocean being much reduced, the dryness of the winter months is thus readily explained.

The average rainfall in ten years has been recorded as between 42 and 43 inches, the heaviest monthly rainfall being in October or September, the lightest in June or July.

The average monthly summer rainfall is 4.20 inches; for winter, 0.50 inch.

The rainfall upon the coast is generally in excess of that inland. This is caused by the not infrequent heavy sea gales brought inland by a strong south wind, the cold wind of the colony. These rains are generally so furious that they expend all their supply upon the coast, only a limited shower drifting inland.

Thunderstorms must also not be overlooked as rain makers. Within recent years there has been a marked diminution of these on the coast, but no such decrease has been noted in the midland and highlands. These thunderstorms are always of high intensity indeed, have gained a certain world renown for their suddenness of onset and brilliancy of display.

To encounter one of these storms, as I have done, amid the weird and hoary peaks of the Drakensberg the very air throbbing with electricity and the sky an immense pall of murky gloom—is an experience as awesome as it is sublime.

Fifty-one thunderstorms have been registered in a single year in Pietermaritzburg, the capital, which lies in a basin at the base of the Kar Kloof Mountains. These storms are of short duration, but are accompanied by heavy rains, which abundantly water the upland terraces of the colony. During the storms there is an excessive radiation of heat, resulting in a low barometer.

In the months of September and October a northwest wind is frequent, a wind of force, heat, and dryness. It is most trying to both animal and vegetable life, its intense dryness being even more exhausting than its actual temperature. It generally blows strongest at night, thus rendering sleeping a very unsuccessful venture. Moreover it is the parent of the sand storm or "dust-devil," which does not belie its name, as it almost lifts you off your feet, at the same time filling your eyes, ears, and mouth with a fine red sand; not infrequently it strikes a military camp and there plays sad havoc, leveling to the ground in broad street-like lanes all tents or movable impediments it encounters as it rushes along in immense sky-reaching gyrations.

The mean yearly temperature at Pietermaritzburg—an elevation of 2,218 feet—is about 66°; on a few summer days it may reach the century mark. Winter is cool and crisp; after sundown a very transient touch of frost may be experienced. The abundance and distribution of the rainfall, however, so modifies the temperature that there is a mean difference of 4° or 5° between the coast climate and that of the upland, a variation sufficiently pronounced to produce a marked difference in their respective vegetation, the semitropical products—tea, coffee, sugar, pineapples, bananas, arrowroot, oranges—of the lowland contrasting with the mealies—wheat, oats, and Kafir corn—of the upland.

The difference of the midsummer and midwinter day is only four hours.

In the sum total of its attributes, Natal—lowland and highland—presents a climate difficult to surpass—an ideal home for the white man. Indeed, even California, with her justly "glorious climate," would find herself somewhat handicapped in competition.

One could, without any exaggeration of conception, picture the Great Cause viewing this offspring of His creation and exclaiming, "Behold, it is very good."

years especially, aerostation has appeared under a new light as an attractive and instructive kind of sport. Only a few years ago ballooning still appeared as a mysterious science, confined exclusively to a few men, sometimes not scientific at all, and many times we have seen celebrated captains, more or less adorned with foreign distinctions, telling of terrific adventures for the benefit of their own glory but not of science.

Matters are changing considerably now, amateurs going more and more for private aerostation, beating by tremendous lengths all the records of the old professionals. That result is chiefly due to the Aéro-Club de France, which I have the honor of representing here. This society, founded in 1898, has now over 500 members, and among them the greatest names in science, art, the military, and sport. Since the foundation of the club over 600 ascents have been made, no one ever meeting with any noticeable accident.

Pilots are every day more numerous, and it is acknowledged that an up-to-date sportsman can not exclude from his education the handling of an aerial crew.

The flotilla of the club is about 50 balloons, and nearly every day ascents are made from the lovely park of St. Cloud, many of them marking far away on the map of Europe the spot of their landing. Apart from scientific interest the sport itself is charming to an extent that the uninitiated can scarcely imagine. The aerial ship glides quietly—no shocks, no dust, no wind noticeable, and whether over land or over clouds the sight is of incomparable beauty. It is impossible to have an idea of the majestic grandeur of such a spectacle. In the midst of atmosphere the aeronaut feels his thoughts enlarging while his light vessel has isolated him from things mundane. The most prosaic man becomes a refined and sentimental poet, and were it only for that reason ballooning should deserve every encouragement. Although the aerial sphere is not steerable, it would be a mistake to think the aeronaut is quite helpless and at the mercy of the wind. By constantly consulting his compass and chart and carefully examining the country underneath, he knows exactly the position, the direction followed, and the speed. Even by night the lights of cities and the glittering of waters are perceived quite distinctly; and if propelled toward the sea, the pilot descends immediately, seeing that he is going in a dangerous direction.

In complete security the aeronaut enjoys the most delicious way of traveling—no frontiers, no custom-house, no policemen. The way is absolutely free, and the uncertainty of the place where the voyage will end is not the least attraction.

Aerostation is a fairy enchantress who makes her slave everyone who approaches her.

Hitherto I have spoken as an aerial enthusiast, and now as a student

of geography, being also the representative of the Société de Géographie of Lille—the most potent society in France outside of Paris—it is my duty to declare that the two sciences, viz, geography and aerostation, are very closely allied, for no better practical lesson in geography can be obtained than by means of an aerial trip, especially a prolonged one. Enormous distances may be covered in that way when the aeronaut is able to make the best use of the various peculiarities of the atmosphere, and knows how to skillfully balance his machine so as to waste as little force, otherwise ballast, as possible. This is a somewhat delicate operation, which necessitates care and much practice. There is no more interesting pleasure than making a long trip across a large portion of the map, perceiving every detail of landscape, towns, villages, rivers, and railways, bounding over mountains and contemplating nature in places where no other man has been before, because no other vehicle but a balloon could possibly reach them. One thus discovers many secrets of the life of different countries that he passes over, such as the richness of the soil, natural products, and industries carried on, and the reason of these things appears more clearly to the mind of the aerial observer. You may be sure then that the memory will retain for a long time the vivid recollection of the whole of such a voyage.

Among the most important modern voyages there are a few French aeronauts who have succeeded in crossing from Paris to the Russian Empire, the longest one being that of the Comte de Vaulx, on board the Centaure, thirty-three hours from Paris to Kiew, among the Cossacks of Ukraine.

Other remarkable voyages have been made by Messrs. Balzan, Castillon de Saint Victor, Mallet, and others. The two last-named aeronauts made a splendid run across northern Europe, crossing the Baltic and landing in Sweden.

I must confess that a few years ago my knowledge of the geography of Europe was very poor indeed, but since then several crossings of central Europe by balloon have done me much good in that respect.

Consequently, I should be glad if my humble words could attract the attention of geographical students to aerostation, which, I can assure them, is not only a most delightful sport, but philosophically the source of grand thought and intellectually a help to every science generally and to geography in particular.

I must ask you, gentlemen, to extend your indulgence to me if I have not been able to express as ably as I should have desired my ideas on the subject of geography and aerostation—which are in my mind so closely allied. I hope to vastly increase my store of knowledge on the former subject by continued study of the latter, and that many other students may be inspired to further study the two subjects in the same way.

CLIMATE OF PAMPLEMOUSSES, IN THE ISLAND OF MAURITIUS

By T. F. CLAXTON, F. R. A. S., Director of the Royal Alfred Observatory

INTRODUCTORY

Meteorological observations have been made at various times and places in Mauritius since the year 1832, when Colônel Lloyd, the surveyor-general at that time, fitted up a small observatory in Port Louis, latitude 20° 10′ south, and longitude 57° 30′ east of Greenwich, and conducted an intermittent series of magnetic and meteorological observations until his departure from the colony in 1849.

A second series was commenced in 1852 by the corps of royal engineers in a building near Colonel Lloyd's observatory, to which the instruments were again transferred in 1859, and the observations continued under the superintendence of Mr. Charles Meldrum, M. A., until 1867.

In that year Mr. Meldrum was authorized to proceed to England to obtain plans and instruments for a new observatory, the Port Louis site having proved objectionable for various reasons.

It was not until the year 1874, however, that these instruments were installed at the new Royal Alfred Observatory, Pamplemousses, of which the foundation stone had been laid on May 30, 1870, by His Royal Highness, the Duke of Edinburgh.

The observations taken in Port Louis from 1860 to 1866 were discussed by Mr. Meldrum in a paper read at a meeting of the British Association for the Advancement of Science held in 1867. Those commenced at Pamplemousses in 1874 form the basis of this paper.

POSITION OF THE OBSERVATORY

The Royal Alfred Observatory, on the island of Mauritius, is situated on a plain about 3 miles from the west coast, and stands in 11 acres of Crown land, 180 feet above mean sea level. The position of the transit instrument is 20° 5′ 39″ south, and $3^h\ 50^m\ 12^s.6$ east of Greenwich.

From west-southwest through west to north there is an uninterrupted view of the sea, and from north through east to southeast the ground generally rises to Mount Piton, the summit of which bears about 4 miles east-southeast and is 917 feet above mean sea level. Between southeast and southwest there is a chain of mountains, the highest peak of which, the Pieterboth, bears nearly 6 miles due south

and has an altitude of 2,874 feet. The nearest extremities of two spurs which run north and northwest from the Pieterboth are at distances of 3 to 4 miles, and have an elevation of about 560 feet.

The island is of volcanic origin, and the rocks are more or less magnetic. Around the observatory the soil has a depth of from 3 to 14 feet, below which is solid basalt.

DAILY NORMALS OF THE METEOROLOGICAL ELEMENTS

In Tables I to X are given the adopted daily and monthly normals of the various meteorological elements. The values in each case are daily ordinates of a hand-smoothed curve of mean daily values. This method was adopted after trial of various mathematical smoothings, none of which sufficiently eliminated accidental irregularities without unduly flattening the curves at maximum and minimum.

Atmospheric pressure.—The normal values have been derived from hourly measures of a Kew pattern barograph from 1875–1899, standardized by eye observations of Newman No. 128, until August 31, 1880; the mean of Negretti and Zambra Nos. 1189 and 1190, from September 1, 1880, to June 23, 1883; Hicks No. 687, from June 24, 1883, to September 24, 1891, and Newman No. 128 (with new tube fitted), since September 25, 1891. The appropriate corrections have been applied to reduce all the observations to one standard of reference (Newman No. 128, with new tube fitted).

Temperature of the air and of evaporation.—Continuous photographic registration of the temperature of the air and of evaporation was commenced in the year 1891. Formerly eye observations of dry and wet bulb thermometers were taken at 6^h, 9^h, 13^h, and 15^h, Mauritius civil time. The thermometers were placed in a lofty room between two open windows. Table II gives the adopted mean temperature of the air on the thermograph screen on every day of the year, as derived from the hourly measures of the thermograms, from 1891 to 1899, and Table III the corresponding temperature in a lofty room (unsmoothed) as derived from eye observations at 6^h and 15^h from 1875 to 1899, after application of the necessary corrections to reduce to thermograph screen.

Elastic force of vapor and relative humidity.—These elements have been computed from the mean (unsmoothed) values of air and evaporation temperatures on the thermograph screen. The values so obtained have been smoothed by hand.

Wind components and resultants.—The separate hourly measures of the anemograms from 1876 to 1899 have been resolved into north and east components, and from the normals given in Tables VII and VIII the resultants in Table IX have been computed. The angles in the latter table represent the direction from which the wind blows, counting from south (0°), east (90°), north (180°), and west (270°). The observed velocity, irrespective of direction, is given in Table X.

TABLE I.—*Adopted daily and monthly normal values of the barometric pressure at the Royal Alfred Observatory, Mauritius.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1	29.778	29.727	29.744	29.794	29.855	29.929	29.994	30.010	30.007	29.972	29.908	29.843
2	29.776	29.726	29.745	29.796	29.857	29.932	29.995	30.010	30.006	29.970	29.906	29.841
3	29.774	29.726	29.747	29.798	29.859	29.935	29.996	30.011	30.006	29.968	29.904	29.839
4	29.772	29.726	29.748	29.800	29.861	29.938	29.997	30.011	30.005	29.966	29.902	29.837
5	29.770	29.725	29.749	29.802	29.864	29.940	29.997	30.011	30.005	29.964	29.900	29.835
6	29.769	29.725	29.750	29.804	29.866	29.943	29.998	30.011	30.004	29.962	29.897	29.833
7	29.767	29.725	29.752	29.806	29.868	29.946	29.999	30.011	30.003	29.960	29.895	29.831
8	29.765	29.725	29.753	29.808	29.870	29.949	30.000	30.011	30.002	29.958	29.893	29.829
9	29.763	29.725	29.755	29.810	29.872	29.952	30.001	30.011	30.001	29.956	29.891	29.827
10	29.761	29.726	29.756	29.811	29.875	29.954	30.001	30.011	30.001	29.954	29.889	29.825
11	29.759	29.726	29.758	29.813	29.877	29.957	30.002	30.011	30.000	29.952	29.887	29.822
12	29.757	29.727	29.759	29.815	29.880	29.959	30.002	30.011	29.999	29.950	29.885	29.820
13	29.755	29.727	29.761	29.817	29.882	29.962	30.003	30.011	29.998	29.948	29.883	29.818
14	29.753	29.727	29.762	29.819	29.885	29.965	30.004	30.011	29.997	29.946	29.881	29.816
15	29.751	29.728	29.764	29.820	29.887	29.967	30.004	30.011	29.996	29.944	29.879	29.814
16	29.749	29.729	29.766	29.822	29.890	29.969	30.005	30.011	29.994	29.942	29.876	29.811
17	29.747	29.730	29.767	29.824	29.892	29.972	30.005	30.011	29.993	29.940	29.874	29.809
18	29.745	29.731	29.769	29.826	29.894	29.974	30.006	30.011	29.991	29.938	29.872	29.807
19	29.743	29.732	29.770	29.828	29.897	29.976	30.007	30.010	29.990	29.936	29.870	29.805
20	29.741	29.733	29.772	29.831	29.899	29.978	30.007	30.010	29.989	29.934	29.868	29.803
21	29.740	29.734	29.774	29.833	29.902	29.979	30.007	30.010	29.988	29.932	29.865	29.800
22	29.738	29.735	29.775	29.835	29.904	29.981	30.007	30.010	29.987	29.930	29.863	29.798
23	29.737	29.736	29.777	29.837	29.907	29.982	30.008	30.010	29.985	29.928	29.861	29.796
24	29.735	29.737	29.779	29.839	29.909	29.934	30.008	30.010	29.984	29.926	29.859	29.794
25	29.734	29.738	29.781	29.842	29.911	29.985	30.008	30.005	29.982	29.924	29.857	29.792
26	29.733	29.739	29.783	29.844	29.914	29.987	30.008	30.009	29.981	29.922	29.894	29.790
27	29.732	29.740	29.784	29.846	29.916	29.988	30.008	30.008	29.979	29.919	29.852	29.788
28	29.731	29.741	29.786	29.848	29.919	29.990	30.009	30.008	29.978	29.917	29.850	29.786
29	29.730	29.743	29.788	29.850	29.921	29.991	30.009	30.008	29.976	29.915	29.848	29.784
30	29.729	......	29.790	29.853	29.924	29.993	30.009	30.007	29.971	29.913	29.846	29.782
31	29.728	......	29.792	......	29.926	......	30.010	30.007	......	29.911	......	29.780
Mean	29.750	29.731	29.766	29.822	29.890	29.965	30.004	30.010	29.993	29.942	29.877	29.811

Mean of the twelve monthly values—29.880 inches.

TABLE II.—*Adopted daily and monthly normal values of the temperature of the air at the Royal Alfred Observatory, Mauritius, from thermograph tabulations.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
1	78.7	78.9	78.0	76.4	73.9	70.0	67.7	67.5	68.6	70.7	73.8	76.8
2	78.7	78.8	78.0	76.3	73.8	69.9	67.7	67.5	68.7	70.8	73.9	77.0
3	78.7	78.8	77.9	76.3	73.7	69.8	67.6	67.5	68.7	70.9	73.9	77.1
4	78.7	78.8	77.9	76.2	73.6	69.7	67.6	67.6	68.8	71.0	74.0	77.2
5	78.8	78.8	77.8	76.1	73.5	69.6	67.6	67.6	68.9	71.0	74.1	77.3
6	78.8	78.8	77.8	76.1	73.4	69.5	67.6	67.6	68.9	71.1	74.2	77.4
7	78.8	78.7	77.8	76.0	73.3	69.4	67.5	67.6	69.0	71.2	74.3	77.5
8	78.8	78.7	77.7	75.9	73.2	69.3	67.5	67.7	69.0	71.3	74.4	77.6
9	78.8	78.7	77.7	75.9	73.1	69.2	67.5	67.7	69.1	71.4	74.5	77.6
10	78.9	78.7	77.6	75.8	72.9	69.1	67.5	67.7	69.1	71.5	74.6	77.7
11	78.9	78.6	77.6	75.8	72.8	69.0	67.4	67.7	69.2	71.6	74.7	77.8
12	78.9	78.6	77.5	75.7	72.7	68.9	67.4	67.8	69.3	71.7	74.8	77.8
13	78.9	78.6	77.5	75.6	72.6	68.8	67.4	67.8	69.4	71.8	74.9	77.9
14	78.9	78.5	77.4	75.5	72.4	68.7	67.4	67.9	69.5	71.9	75.0	78.0
15	78.9	78.5	77.3	75.4	72.3	68.6	67.4	67.9	69.5	72.0	75.1	78.0
16	78.9	78.5	77.3	75.4	72.2	68.5	67.4	67.9	69.6	72.1	75.2	78.1
17	78.9	78.5	77.2	75.3	72.0	68.4	67.4	68.0	69.7	72.2	75.3	78.1
18	79.0	78.5	77.2	75.2	71.9	68.4	67.4	68.0	69.7	72.3	75.4	78.2
19	79.0	78.4	77.1	75.1	71.7	68.3	67.4	68.0	69.8	72.4	75.5	78.2
20	79.0	78.4	77.1	75.0	71.6	68.2	67.4	68.1	69.9	72.5	75.6	78.3
21	79.0	78.3	77.0	74.9	71.5	68.2	67.4	68.1	70.0	72.6	75.7	78.3
22	78.9	78.3	77.0	74.3	71.3	68.1	67.3	68.2	70.1	72.7	75.8	78.4
23	78.9	78.3	76.9	74.7	71.2	68.1	67.4	68.2	70.1	72.8	75.9	78.4
24	78.9	78.2	76.9	74.6	71.0	68.0	67.4	68.2	70.2	72.9	76.0	78.4
25	78.9	78.2	76.8	74.5	70.9	67.9	67.4	68.3	70.2	73.0	76.1	78.5
26	78.9	78.1	76.7	74.4	70.8	67.9	67.4	68.3	70.3	73.2	76.2	78.5
27	78.9	78.1	76.7	74.3	70.7	67.9	67.4	68.4	70.4	73.3	76.3	78.5
28	78.9	78.1	76.6	74.2	70.5	67.8	67.4	68.4	70.5	73.4	76.4	78.6
29	78.9	78.0	76.6	74.1	70.4	67.8	67.4	68.5	70.6	73.5	76.6	78.6
30	78.9	......	76.5	74.0	70.3	67.7	67.4	68.5	70.6	73.6	76.7	78.6
31	78.9	......	76.5	......	70.2	......	67.5	68.6	......	73.7	......	78.6
Mean	78.9	78.5	77.3	75.3	72.1	68.7	67.5	68.0	69.6	72.1	75.2	78.0

Mean of the twelve monthly values 73.42°.

TABLE III.—*Mean daily temperature of the air in a lofty room at the Royal Alfred Observatory, Mauritius, 1875–1899 (after correction to reduce to thermograph screen).*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
1	78.6	78.9	77.7	77.1	73.7	70.0	68.3	67.4	68.6	70.7	73.7	76.6
2	79.0	78.8	77.5	77.2	73.8	70.1	67.8	68.0	68.7	70.9	73.9	77.4
3	79.1	78.5	77.9	77.0	74.2	70.1	68.1	67.8	68.8	70.9	74.0	77.1
4	78.7	78.6	77.8	77.0	74.8	70.3	68.4	68.1	69.0	71.6	74.0	77.1
5	78.8	78.8	77.3	76.7	73.7	70.0	68.3	68.5	68.9	71.1	73.9	76.9
6	78.8	78.5	77.6	76.5	73.4	70.2	67.9	68.1	69.0	70.7	73.8	77.1
7	78.5	78.6	77.7	76.4	73.1	70.0	68.1	68.2	69.3	71.1	74.0	77.7
8	78.9	78.8	78.2	76.3	72.4	70.1	68.0	68.1	69.2	71.0	74.4	78.1
9	78.6	79.0	78.3	76.4	72.1	69.5	67.9	68.3	69.3	71.4	74.8	78.4
10	78.7	78.5	77.9	76.3	72.1	69.1	68.1	68.3	69.4	71.5	75.2	77.6
11	78.6	78.4	77.6	76.4	72.3	68.6	67.8	67.9	69.3	71.7	74.7	78.0
12	78.8	78.4	77.6	76.1	72.3	68.8	67.9	68.0	69.8	71.5	75.1	77.6
13	79.2	78.5	77.9	75.5	71.8	68.6	67.5	68.2	69.4	71.4	75.2	77.8
14	79.0	78.4	77.7	75.6	72.0	68.7	67.7	68.3	69.9	72.0	75.1	78.0
15	78.8	78.2	77.4	75.6	72.0	68.8	67.9	67.8	70.0	72.1	74.9	78.0
16	79.1	78.5	77.7	76.0	72.0	68.3	67.8	68.1	69.7	71.9	75.0	77.9
17	78.9	78.8	77.6	75.5	71.9	68.6	68.0	68.4	70.2	72.2	75.3	78.0
18	79.2	79.1	77.4	75.6	72.1	68.6	67.8	68.1	70.1	71.8	75.5	78.0
19	79.4	78.0	77.2	75.2	72.2	68.7	67.8	68.3	70.1	72.0	75.8	78.2
20	79.0	78.5	77.5	75.0	72.1	68.6	68.1	68.0	70.2	72.4	75.8	78.5
21	78.8	78.6	77.5	74.9	71.7	68.6	67.7	68.5	70.3	72.6	76.1	78.4
22	79.2	78.7	77.3	75.3	71.5	68.5	67.7	68.3	70.2	73.0	75.9	78.2
23	79.4	78.7	77.3	75.1	71.4	68.5	67.6	68.3	70.8	73.1	75.9	78.2
24	79.2	78.7	77.4	75.0	71.4	68.7	67.9	68.5	71.2	73.3	76.5	78.4
25	79.3	78.5	77.5	74.9	70.6	68.7	67.7	68.5	71.1	73.4	76.6	78.6
26	79.3	78.1	77.1	74.9	70.9	68.1	67.5	68.5	70.8	73.3	76.4	78.9
27	79.1	78.5	77.2	75.1	70.9	68.3	67.3	68.6	70.6	73.5	76.2	78.5
28	78.9	78.2	77.3	75.1	70.7	68.4	67.5	68.8	70.3	73.5	76.5	78.5
29	78.8	78.2	77.2	74.8	71.1	68.2	67.8	69.0	70.4	73.0	76.5	78.6
30	78.9	....	77.2	74.5	70.8	68.1	68.0	69.1	70.5	73.4	77.0	78.6
31	79.0	....	77.2	....	70.3	....	67.8	68.7	....	73.8	....	78.9
Mean	78.95	78.55	77.54	75.77	72.09	68.99	67.86	68.28	69.84	72.12	75.26	77.99

TABLE IV.—*Adopted daily and monthly normal values of the temperature of evaporation at the Royal Alfred Observatory, Mauritius.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
1	73.3	74.1	73.9	72.6	70.0	65.8	63.4	63.0	63.6	65.1	67.4	70.6
2	73.2	74.1	73.9	72.5	69.9	65.7	63.4	63.0	63.6	65.2	67.5	70.8
3	73.4	74.1	73.8	72.4	69.8	65.5	63.3	63.0	63.7	65.2	67.6	70.9
4	73.4	74.1	73.8	72.3	69.7	65.4	63.3	63.0	63.7	65.3	67.7	71.0
5	73.5	74.1	73.8	72.3	69.6	65.2	63.3	63.0	63.8	65.4	67.7	71.1
6	73.5	74.1	73.7	72.2	69.5	65.1	63.2	63.0	63.8	65.5	67.8	71.2
7	73.5	74.1	73.7	72.2	69.4	65.0	63.2	63.0	63.8	65.5	67.9	71.3
8	73.6	74.1	73.7	72.1	69.3	64.9	63.2	63.0	63.9	65.6	68.0	71.4
9	73.6	74.1	73.6	72.0	69.1	64.8	63.2	63.0	63.9	65.7	68.1	71.5
10	73.6	74.1	73.6	72.0	69.0	64.7	63.2	63.1	64.0	65.7	68.2	71.6
11	73.7	74.1	73.6	71.9	68.9	64.6	63.1	63.1	64.0	65.8	68.3	71.7
12	73.7	74.1	73.5	71.8	68.7	64.5	63.1	63.1	64.1	65.9	68.4	71.8
13	73.7	74.1	73.5	71.7	68.6	64.5	63.1	63.1	64.1	66.0	68.5	71.9
14	73.8	74.1	73.4	71.6	68.5	64.4	63.1	63.1	64.2	66.0	68.6	72.0
15	73.8	74.1	73.4	71.5	68.3	64.3	63.1	63.1	64.2	66.1	68.7	72.1
16	73.8	74.1	73.4	71.5	68.1	64.2	63.0	63.1	64.3	66.2	68.8	72.2
17	73.9	74.1	73.3	71.4	67.9	64.1	63.0	63.1	64.3	66.2	68.9	72.3
18	73.9	74.1	73.3	71.3	67.8	64.1	63.0	63.2	64.4	66.3	69.0	72.4
19	73.9	74.1	73.2	71.2	67.6	64.0	63.0	63.2	64.4	66.4	69.1	72.4
20	73.9	74.1	73.2	71.1	67.5	63.9	63.0	63.2	64.5	66.4	69.2	72.5
21	74.0	74.0	73.1	71.0	67.3	63.9	63.0	63.2	64.6	66.5	69.3	72.6
22	74.0	74.0	73.1	70.9	67.2	63.8	63.0	63.3	64.6	66.6	69.4	72.7
23	74.0	74.0	73.0	70.8	67.0	63.8	63.0	63.3	64.7	66.7	69.5	72.7
24	74.0	74.0	73.0	70.7	66.9	63.7	63.0	63.3	64.7	66.7	69.7	72.8
25	74.0	74.0	72.9	70.6	66.7	63.7	63.0	63.3	64.8	66.8	69.8	72.8
26	74.0	74.0	72.9	70.5	66.6	63.6	63.0	63.4	64.9	66.9	69.9	72.9
27	74.0	73.9	72.8	70.4	66.4	63.6	63.0	63.4	64.9	67.0	70.1	73.0
28	74.0	73.9	72.8	70.3	66.3	63.5	63.0	63.4	65.0	67.1	70.2	73.0
29	74.0	73.9	72.7	70.2	66.2	63.5	63.0	63.5	65.0	67.1	70.4	73.1
30	74.1	....	72.7	70.1	66.0	63.4	63.0	63.5	65.1	67.2	70.5	73.2
31	74.1	....	72.6	....	65.9	....	63.0	63.5	....	67.3	....	73.2
Mean	73.8	74.1	73.3	71.4	68.1	64.4	63.1	63.2	64.3	66.2	68.8	72.1

Mean of the twelve monthly values =69.57°.

TABLE V.—*Adapted daily and monthly normal values of the vapor tension at the Royal Alfred Observatory, Mauritius.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1	0.716	0.754	0.756	0.731	0.668	0.572	0.512	0.505	0.512	0.535	0.574	0.637
2	.716	.754	.756	.728	.666	.570	.512	.505	.514	.585	.576	.639
3	.718	.754	.756	.728	.664	.566	.511	.505	.514	.537	.578	.644
4	.721	.754	.756	.726	.661	.564	.511	.505	.514	.537	.580	.646
5	.723	.756	.756	.726	.659	.560	.511	.505	.514	.539	.582	.648
6	.723	.756	.754	.723	.657	.558	.511	.505	.516	.539	.584	.650
7	.726	.756	.754	.721	.655	.554	.509	.505	.516	.541	.586	.652
8	.728	.756	.754	.721	.650	.552	.509	.505	.516	.541	.588	.655
9	.728	.756	.754	.718	.648	.550	.509	.505	.518	.543	.590	.657
10	.731	.756	.754	.716	.646	.548	.509	.505	.518	.543	.592	.661
11	.733	.756	.751	.716	.641	.545	.507	.507	.518	.545	.592	.664
12	.733	.759	.751	.713	.639	.548	.507	.507	.520	.546	.594	.666
13	.736	.759	.751	.711	.637	.541	.507	.507	.520	.546	.596	.668
14	.736	.759	.751	.708	.633	.539	.507	.507	.520	.548	.598	.671
15	.738	.759	.751	.706	.630	.537	.507	.507	.522	.550	.601	.673
16	.738	.759	.749	.704	.626	.535	.507	.507	.522	.550	.603	.675
17	.741	.759	.749	.704	.624	.533	.505	.507	.522	.552	.605	.680
18	.741	.759	.749	.701	.620	.531	.505	.507	.524	.552	.607	.682
19	.744	.759	.746	.699	.615	.529	.505	.509	.524	.554	.609	.684
20	.744	.759	.746	.697	.613	.528	.505	.509	.524	.556	.611	.687
21	.746	.759	.744	.694	.609	.526	.505	.509	.526	.558	.613	.689
22	.746	.759	.744	.692	.607	.524	.505	.509	.526	.558	.615	.692
23	.746	.759	.744	.689	.603	.522	.505	.509	.528	.560	.617	.694
24	.749	.759	.741	.687	.598	.522	.505	.509	.528	.562	.620	.697
25	.749	.756	.741	.684	.596	.520	.505	.509	.529	.564	.622	.699
26	.749	.756	.738	.682	.592	.518	.503	.511	.529	.564	.626	.701
27	.751	.756	.738	.680	.590	.516	.503	.511	.531	.566	.628	.704
28	.751	.756	.736	.678	.586	.516	.503	.511	.531	.568	.630	.706
29	.751	.756	.736	.675	.584	.514	.503	.511	.531	.570	.633	.708
30	.751	....	.733	.671	.580	.514	.505	.512	.533	.570	.635	.711
31	.751	....	.733	....	.576	....	.505	.512	....	.572	....	.713
Mean	.737	.757	.747	.704	.625	.538	.507	.508	.522	.552	.603	.676

Mean of the twelve monthly values=0.623.

TABLE VI.—*Adopted daily and monthly normal values of the relative humidity at the Royal Alfred Observatory, Mauritius.*

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	73	76	79	81	80	78	76	75	73	71	69	70
2	73	76	79	81	80	78	76	75	73	71	69	70
3	73	76	79	81	80	77	76	75	73	71	69	70
4	74	77	79	81	80	77	76	75	73	71	68	70
5	74	77	80	81	80	77	76	75	73	71	68	70
6	74	77	80	81	80	77	76	75	73	71	68	70
7	74	77	80	81	80	77	76	75	73	71	68	70
8	74	77	80	81	80	77	76	75	73	71	68	70
9	75	77	80	81	80	77	76	75	72	71	68	71
10	75	77	80	81	80	77	76	75	72	71	68	71
11	75	77	80	81	80	77	76	75	72	70	68	71
12	75	77	80	81	80	76	76	75	72	70	68	71
13	75	77	80	81	80	76	76	75	72	70	68	71
14	75	77	80	81	80	76	75	75	72	70	68	71
15	75	77	80	81	80	76	76	75	72	70	68	71
16	75	78	80	81	79	76	76	75	72	70	68	71
17	76	78	80	81	79	76	76	75	72	70	68	71
18	76	78	80	81	79	76	76	75	72	70	68	71
19	76	78	80	81	79	76	76	74	71	70	68	71
20	76	79	80	81	79	76	76	74	71	70	68	71
21	76	79	80	81	79	76	76	74	71	70	68	71
22	76	79	81	81	79	76	76	74	71	70	69	71
23	76	79	81	81	79	76	76	74	71	70	69	71
24	76	79	81	81	79	76	75	74	71	70	69	71
25	76	79	81	81	78	76	75	74	71	69	69	71
26	76	79	81	81	78	76	75	74	71	69	69	72
27	76	79	81	80	78	76	75	74	71	69	69	72
28	76	79	81	80	78	76	75	74	71	69	69	72
29	76	79	81	80	78	76	75	74	71	69	69	72
30	76	....	81	80	78	76	75	73	71	69	69	72
31	76	....	81	....	78	....	75	73	....	69	....	72
Mean	75.1	77.7	80.0	80.9	79.3	76.4	75.7	74.5	71.9	70.1	68.4	70.9

Mean of the twelve monthly values=75.08.

Table VII.—*Adopted daily and monthly normal values of the north component of the wind at the Royal Alfred Observatory, Mauritius.*

[Miles per hour.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	+0.12	-1.05	-1.41	-2.25	-3.40	-4.48	-4.98	-4.47	3.91	-2.67	-1.44	-0.54
2	+ .05	-1.06	-1.42	-2.30	-3.43	-4.54	-4.96	-4.45	-3.88	-2.61	-1.41	- .50
3	.00	-1.08	-1.43	-2.36	-3.45	-4.59	-4.94	-4.44	3.86	-2.55	1.38	.47
4	- .05	-1.10	-1.44	-2.41	-3.48	-4.64	-4.92	-4.42	3.84	-2.50	-1.36	- .43
5	.09	-1.11	-1.45	-2.46	-3.50	-4.68	-4.90	-4.41	-3.82	-2.45	-1.33	- .39
6	.14	-1.13	-1.46	-2.50	-3.53	-4.72	-4.87	-4.40	-3.79	-2.40	-1.30	- .36
7	- .17	-1.15	-1.47	-2.55	-3.56	-1.77	-4.85	-4.39	-3.77	-2.35	-1.27	- .32
8	.21	-1.16	-1.48	-2.60	-3.59	-4.82	-4.82	-4.38	-3.76	-2.30	-1.25	- .28
9	.25	-1.17	-1.49	-2.64	-3.62	-4.86	4.80	-4.36	-3.71	-2.26	-1.22	- .24
10	.30	-1.19	-1.50	-2.68	-3.64	-4.91	4.78	-4.35	-3.66	-2.22	-1.19	- .20
11	.34	-1.20	-1.52	-2.72	-3.67	-4.97	4.76	-4.33	-3.61	-2.18	-1.16	- .16
12	.39	-1.22	-1.54	-2.76	-3.70	-5.01	-4.74	4.31	-3.56	-2.14	-1.14	- .12
13	.44	-1.23	-1.55	-2.80	3.73	5.05	-4.72	4.30	-3.53	-2.09	-1.11	- .07
14	.48	-1.24	-1.57	-2.85	-3.76	-5.08	-4.70	-4.28	-3.48	-2.04	-1.08	- .02
15	- .52	-1.25	-1.59	-2.90	-3.79	-5.11	-4.68	-4.26	-3.45	-2.00	-1.06	+ .02
16	- .56	-1.26	-1.61	-2.93	-3.82	-5.14	-4.66	-4.25	-3.41	-1.96	-1.02	+ .08
17	- .59	-1.28	-1.64	-2.96	-3.85	-5.16	-4.64	-4.24	-3.38	-1.92	- .98	+ .13
18	- .62	-1.29	-1.67	-2.99	3.89	-5.17	-4.63	4.22	-3.35	-1.88	- .95	+ .18
19	.66	-1.30	-1.71	-3.02	-3.92	-5.16	-4.62	4.20	3.31	-1.85	- .93	+ .22
20	- .69	-1.31	-1.73	-3.05	-3.95	-5.16	-4.61	-4.18	-3.26	-1.81	- .90	+ .26
21	- .72	-1.32	-1.77	-3.09	-3.99	-5.15	4.59	4.16	3.22	-1.78	- .87	+ .30
22	- .76	-1.33	-1.81	-3.13	-4.02	-5.14	4.57	-4.14	-3.17	-1.75	- .84	+ .34
23	- .79	-1.34	-1.86	3.16	-4.05	-5.13	4.56	-4.12	-3.12	-1.72	- .81	+ .38
24	- .82	-1.35	-1.91	-3.19	-4.10	-5.11	-4.55	-4.11	-3.06	-1.69	- .78	+ .42
25	- .85	-1.36	-1.96	-3.22	-4.14	5.10	4.54	-4.09	-3.00	-1.66	- .74	+ .42
26	- .88	-1.37	-2.00	-3.25	-4.18	5.08	-4.53	-4.07	-2.95	-1.63	- .71	+ .40
27	- .91	-1.38	2.05	-3.28	-4.22	-5.07	-4.52	-4.05	-2.90	-1.60	- .67	+ .37
28	- .94	-1.39	-2.09	-3.31	-4.27	-5.06	-4.51	-4.02	-2.84	-1.57	.64	+ .32
29	- .97	-1.40	-2.13	-3.35	-4.31	-5.03	-4.50	-4.00	-2.78	-1.53	.60	+ .28
30	-1.00	....	-2.17	-3.37	-4.37	-5.01	-4.49	-3.97	-2.73	-1.50	- .57	+ .22
31	-1.02	....	-2.21	....	-4.42	....	-4.48	-3.94	....	-1.47	....	+ .17
Mean	- .52	-1.24	-1.70	-2.87	-3.85	-4.96	-4.69	-4.24	-3.40	-2.00	-1.02	+ .13

Mean of the twelve monthly values = −2.53.

Table VIII.—*Adopted daily and monthly normal values of the east component of the wind at the Royal Alfred Observatory, Mauritius.*

[Miles per hour.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.46	8.25	7.87	8.03	8.01	8.40	9.38	10.13	10.44	9.66	8.89	8.62
2	8.46	8.23	7.86	8.04	8.01	8.43	9.41	10.15	10.43	9.62	8.87	8.62
3	8.46	8.21	7.86	8.05	8.01	8.46	9.44	10.17	10.42	9.58	8.86	8.61
4	8.46	8.19	7.85	8.06	8.02	8.49	9.47	10.19	10.41	9.54	8.85	8.60
5	8.46	8.17	7.85	8.07	8.02	8.52	9.50	10.21	10.40	9.50	8.84	8.59
6	8.45	8.15	7.85	8.07	8.02	8.55	9.53	10.23	10.38	9.45	8.83	8.59
7	8.45	8.13	7.85	8.08	8.02	8.59	9.56	10.24	10.37	9.41	8.82	8.58
8	8.45	8.11	7.85	8.08	8.02	8.62	9.60	10.26	10.35	9.38	8.81	8.57
9	8.45	8.09	7.85	8.09	8.03	8.65	9.63	10.27	10.34	9.35	8.80	8.57
10	8.45	8.08	7.85	8.09	8.03	8.68	9.66	10.29	10.33	9.32	8.79	8.56
11	8.45	8.06	7.85	8.10	8.04	8.72	9.69	10.31	10.31	9.28	8.78	8.55
12	8.44	8.04	7.85	8.10	8.05	8.75	9.72	10.32	10.29	9.25	8.77	8.55
13	8.44	8.03	7.86	8.10	8.06	8.78	9.74	10.34	10.27	9.22	8.76	8.54
14	8.43	8.02	7.86	8.09	8.07	8.81	9.76	10.35	10.23	9.19	8.76	8.54
15	8.42	8.01	7.86	8.09	8.08	8.85	9.79	10.37	10.21	9.17	8.75	8.53
16	8.42	7.99	7.87	8.09	8.10	8.88	9.81	10.38	10.18	9.15	8.74	8.52
17	8.41	7.98	7.87	8.09	8.11	8.92	9.83	10.39	10.15	9.13	8.73	8.52
18	8.40	7.97	7.88	8.08	8.12	8.95	9.86	10.40	10.12	9.11	8.72	8.52
19	8.39	7.96	7.89	8.07	8.14	8.98	9.88	10.41	10.09	9.08	8.71	8.51
20	8.38	7.95	7.90	8.06	8.15	9.01	9.90	10.42	10.05	9.06	8.70	8.50
21	8.38	7.94	7.91	8.05	8.17	9.05	9.92	10.43	10.01	9.05	8.69	8.50
22	8.37	7.93	7.92	8.05	8.19	9.08	9.94	10.43	9.98	9.03	8.69	8.49
23	8.36	7.92	7.93	8.04	8.21	9.11	9.96	10.43	9.94	9.01	8.68	8.49
24	8.35	7.91	7.94	8.04	8.23	9.14	9.98	10.44	9.91	9.00	8.67	8.48
25	8.34	7.90	7.95	8.03	8.25	9.17	10.00	10.44	9.88	8.98	8.67	8.48
26	8.32	7.90	7.96	8.03	8.27	9.21	10.02	10.45	9.84	8.96	8.66	8.48
27	8.31	7.89	7.97	8.02	8.29	9.24	10.04	10.45	9.80	8.95	8.65	8.48
28	8.30	7.89	7.98	8.02	8.31	9.27	10.06	10.45	9.76	8.94	8.64	8.47
29	8.28	7.88	7.99	8.01	8.33	9.31	10.08	10.45	9.73	8.93	8.64	8.47
30	8.27	....	8.01	8.01	8.35	9.34	10.10	10.45	9.70	8.92	8.63	8.47
31	8.26	....	8.02	....	8.37	....	10.11	10.45	....	8.90	....	8.46
Mean	8.40	8.03	7.90	8.06	8.13	8.87	9.79	10.35	10.14	9.20	8.75	8.53

Mean of the twelve monthly values = 8.846.

TABLE IX.—*Mean daily and monthly normal direction and velocity of the wind at the Royal Alfred Observatory, Mauritius.*

[Velocity of the wind in miles per hour

Day.	January. Direction.	January. Velocity.	February. Direction.	February. Velocity.	March. Direction.	March. Velocity.	April. Direction.	April. Velocity.	May. Direction.	May. Velocity.	June. Direction.	June. Velocity.
	°		°		°		°		°		°	
1	91	8.5	83	8.3	80	8.0	74	8.4	67	8.7	62	9.5
2	90	8.5	83	8.3	80	8.0	74	8.4	67	8.7	62	9.6
3	90	8.5	83	8.3	80	8.0	74	8.4	67	8.7	61	9.6
4	89	8.5	82	8.2	80	8.0	73	8.4	67	8.8	61	9.7
5	89	8.5	82	8.2	80	8.0	73	8.4	66	8.8	61	9.7
6	89	8.5	82	8.2	79	8.0	73	8.5	66	8.8	61	9.8
7	89	8.5	82	8.2	79	8.0	72	8.5	66	8.8	61	9.8
8	89	8.5	82	8.2	79	8.0	72	8.5	66	8.8	61	9.9
9	88	8.5	82	8.2	79	8.0	72	8.5	66	8.8	61	9.9
10	88	8.5	82	8.2	79	8.0	72	8.5	66	8.8	61	10.0
11	88	8.5	82	8.2	79	8.0	71	8.6	65	8.8	60	10.0
12	87	8.4	81	8.1	79	8.0	71	8.6	65	8.8	60	10.1
13	87	8.4	81	8.1	79	8.0	71	8.6	65	8.8	60	10.1
14	87	8.4	81	8.1	79	8.0	71	8.6	65	8.9	60	10.2
15	86	8.4	81	8.1	79	8.0	70	8.6	65	8.9	60	10.2
16	86	8.4	81	8.1	78	8.1	70	8.6	65	8.9	60	10.3
17	86	8.4	81	8.1	78	8.1	70	8.6	65	8.9	60	10.3
18	86	8.4	81	8.1	78	8.1	70	8.6	64	9.0	60	10.3
19	86	8.4	81	8.1	78	8.1	69	8.6	64	9.0	60	10.4
20	85	8.4	81	8.1	78	8.1	69	8.6	64	9.0	60	10.4
21	85	8.4	81	8.0	77	8.1	69	8.6	64	9.1	60	10.4
22	85	8.4	80	8.0	77	8.1	69	8.6	64	9.1	60	10.4
23	85	8.4	80	8.0	77	8.2	69	8.6	64	9.1	61	10.5
24	84	8.4	80	8.0	76	8.2	68	8.6	64	9.2	61	10.5
25	84	8.3	80	8.0	76	8.2	68	8.6	63	9.2	61	10.5
26	84	8.3	80	8.0	76	8.3	68	8.7	63	9.3	61	10.5
27	84	8.3	80	8.0	76	8.3	68	8.7	63	9.3	61	10.5
28	84	8.3	80	8.0	75	8.3	68	8.7	63	9.3	61	10.6
29	83	8.3	80	8.0	75	8.3	67	8.7	63	9.4	62	10.6
30	83	8.3			75	8.3	67	8.7	62	9.4	62	10.6
31	83	8.3	......	......	75	8.3	......	......	62	9.5	......	......
	° '		° '		° '		° '		° '		° '	
Mean	86.27	8.42	81.13	8.13	77.51	8.08	70.24	8.56	64.40	9.00	60.47	10.16

Day.	July. Direction.	July. Velocity.	August. Direction.	August. Velocity.	September. Direction.	September. Velocity.	October. Direction.	October. Velocity.	November. Direction.	November. Velocity.	December. Direction.	December. Velocity.
	°		°		°		°		°		°	
1	62	10.6	66	11.1	69	11.1	75	10.0	81	9.0	86	8.6
2	62	10.6	66	11.1	70	11.1	75	10.0	81	9.0	87	8.6
3	62	10.7	66	11.1	70	11.1	75	9.9	81	9.0	87	8.6
4	63	10.7	67	11.1	70	11.1	75	9.9	81	9.0	87	8.6
5	63	10.7	67	11.1	70	11.1	76	9.8	81	8.9	87	8.6
6	63	10.7	67	11.1	70	11.1	76	9.8	82	8.9	88	8.6
7	63	10.7	67	11.1	70	11.0	76	9.7	82	8.9	88	8.6
8	63	10.8	67	11.1	70	11.0	76	9.7	82	8.9	88	8.6
9	64	10.8	67	11.2	70	11.0	76	9.6	82	8.9	88	8.6
10	64	10.8	67	11.2	70	11.0	77	9.6	82	8.9	89	8.6
11	64	10.8	67	11.2	71	10.9	77	9.6	82	8.9	89	8.5
12	64	10.8	67	11.2	71	10.9	77	9.5	83	8.8	89	8.5
13	64	10.8	67	11.2	71	10.9	77	9.5	83	8.8	90	8.5
14	64	10.9	68	11.2	71	10.8	77	9.4	83	8.8	90	8.5
15	64	10.9	68	11.2	71	10.8	78	9.4	83	8.8	90	8.5
16	65	10.9	68	11.2	72	10.7	78	9.4	83	8.8	91	8.5
17	65	10.9	68	11.2	72	10.7	78	9.3	84	8.8	91	8.5
18	65	10.9	68	11.2	72	10.6	78	9.3	84	8.8	91	8.5
19	65	10.9	68	11.2	72	10.6	78	9.3	84	8.8	91	8.5
20	65	10.9	68	11.2	72	10.6	79	9.3	84	8.7	92	8.5
21	65	10.9	68	11.2	72	10.5	79	9.2	84	8.7	92	8.5
22	65	11.0	68	11.2	72	10.5	79	9.2	84	8.7	92	8.5
23	65	11.0	68	11.2	73	10.4	79	9.2	85	8.7	93	8.5
24	65	11.0	69	11.2	73	10.4	79	9.2	85	8.7	93	8.5
25	66	11.0	69	11.2	73	10.3	80	9.1	85	8.7	93	8.5
26	66	11.0	69	11.2	73	10.3	80	9.1	85	8.7	93	8.5
27	66	11.0	69	11.2	73	10.2	80	9.1	86	8.7	92	8.5
28	66	11.0	69	11.2	74	10.2	80	9.1	86	8.7	92	8.5
29	66	11.0	69	11.2	74	10.2	80	9.1	86	8.7	92	8.5
30	66	11.1	69	11.2	74	10.1	80	9.0	86	8.7	91	8.5
31	66	11.1	69	11.2	......	10.1	81	9.0	......	......	91	8.5
	° '		° '		° '		° '		° '		° '	
Mean	64.24	10.86	67.43	11.18	71.28	10.69	77.44	9.41	83.21	8.81	90.52	8.53

Mean annual direction = 74° 2'; velocity = 9.20 miles per hour.

The angle represents the azimuth from which the wind blows, counting from south (0°), east (90°), north (180°), west (270°). The velocity is given in miles per hour.

TABLE X.—*Adopted daily and monthly normal values of the velocity of the wind, irrespective of direction, at Royal Alfred Observatory, Mauritius.*

[Velocity of the wind in miles per hour.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	11.0	11.1	10.8	10.4	10.5	10.4	11.9	11.9	12.6	11.5	10.7	10.7
2	11.0	11.1	10.8	10.4	10.5	10.4	12.0	11.9	12.5	11.4	10.7	10.7
3	11.0	11.1	10.7	10.4	10.5	10.5	12.0	11.9	12.5	11.4	10.7	10.7
4	11.0	11.1	10.7	10.4	10.4	10.5	12.0	11.9	12.5	11.3	10.7	10.7
5	11.0	11.1	10.7	10.4	10.4	10.6	12.0	12.0	12.4	11.3	10.7	10.7
6	11.0	11.1	10.6	10.4	10.4	10.7	12.0	12.0	12.4	11.3	10.7	10.7
7	11.0	11.1	10.6	10.5	10.4	10.7	12.0	12.0	12.3	11.2	10.7	10.7
8	11.0	11.1	10.5	10.5	10.4	10.8	12.0	12.1	12.3	11.2	10.7	10.7
9	11.0	11.1	10.5	10.5	10.4	10.8	12.0	12.1	12.3	11.2	10.7	10.7
10	11.0	11.1	10.5	10.5	10.3	10.9	12.0	12.1	12.2	11.1	10.7	10.7
11	11.1	11.0	10.4	10.5	10.3	11.0	12.0	12.2	12.2	11.1	10.7	10.8
12	11.1	11.0	10.4	10.5	10.3	11.0	12.0	12.2	12.1	11.0	10.7	10.8
13	11.1	11.0	10.4	10.6	10.3	11.1	12.0	12.3	12.1	11.0	10.7	10.8
14	11.1	11.0	10.4	10.6	10.2	11.2	12.0	12.3	12.1	11.0	10.7	10.8
15	11.1	11.0	10.3	10.6	10.2	11.2	12.0	12.4	12.0	10.9	10.7	10.8
16	11.1	11.0	10.3	10.6	10.2	11.3	12.0	12.4	12.0	10.9	10.7	10.8
17	11.1	11.0	10.3	10.6	10.2	11.3	12.0	12.5	12.0	10.9	10.7	10.8
18	11.1	11.0	10.3	10.6	10.2	11.4	12.0	12.5	11.9	10.9	10.7	10.8
19	11.1	11.0	10.3	10.6	10.1	11.4	12.0	12.5	11.9	10.9	10.7	10.8
20	11.1	10.0	10.3	10.6	10.1	11.5	12.0	12.6	11.8	10.9	10.7	10.8
21	11.1	10.9	10.3	10.6	10.1	11.5	11.9	12.6	11.8	10.9	10.7	10.8
22	11.1	10.9	10.3	10.6	10.1	11.6	11.9	12.6	11.8	10.8	10.7	10.8
23	11.1	10.9	10.3	10.6	10.1	11.6	11.9	12.6	11.7	10.8	10.7	10.8
24	11.1	10.9	10.3	10.6	10.2	11.7	11.9	12.6	11.7	10.8	10.7	10.8
25	11.1	10.9	10.3	10.6	10.2	11.7	11.9	12.7	11.7	10.8	10.7	10.8
26	11.1	10.9	10.3	10.6	10.2	11.8	11.9	12.6	11.6	10.8	10.7	10.9
27	11.1	10.8	10.3	10.6	10.2	11.8	11.9	12.6	11.6	10.8	10.7	10.9
28	11.1	10.8	10.3	10.5	10.2	11.8	11.9	12.6	11.6	10.7	10.7	10.9
29	11.1	10.8	10.3	10.5	10.3	11.9	11.9	12.6	11.5	10.7	10.7	10.9
30	11.1	....	10.3	10.5	10.3	11.9	11.9	12.6	11.5	10.7	10.7	10.9
31	11.1	....	10.3	....	10.3	....	11.9	12.6	....	10.7	....	10.9
Mean	11.07	10.99	10.42	10.51	10.27	11.19	11.96	12.34	12.02	11.00	10.70	10.79

Mean of the twelve monthly values = 11.10 miles per hour.

ANNUAL INEQUALITY—HARMONIC ANALYSIS

Annual inequality.—In Table XI is given the annual inequality of the meteorological elements. The numbers in the table are the monthly normals diminished by the smallest monthly value in each case.

Harmonic analysis.—They have been subjected to harmonic analysis and the results given in Table XI. It should be mentioned that in the case of atmospheric pressure, air temperature, and evaporation temperature, the equidistant points on the hand-smoothed curves have been used for the analysis.

TABLE XI.—*Annual inequality (each element is diminished by the smallest monthly value).*

Month. \ Element.	Atmospheric pressure.	Air temperature.	Evaporation temperature.	Vapor tension.	Relative humidity.	Possible sunshine.	Amount of cloud.	Rainfall.	Wind. Components. North.	Wind. Components. East.	Wind. Resultants. Direction.	Wind. Resultants. Velocity.	Direction of upper clouds.
	Inch.	°	°	*Inch.*	*P. ct.*	*P. ct.*	*P. ct.*	*In.*	*m.p.h.*	*m.p.h*	°	*m. p. h.*	°
January	0.019	11.4	10.7	0.230	7	3.3	15	6.2	4.44	0.50	25.7	0.34	67
February	.000	11.0	11.0	.250	9	1.3	14	6.6	3.72	0.13	20.4	0.05	65
March	.035	9.8	10.2	.240	12	0.0	15	8.6	3.26	0.00	17.1	0.00	68
April	.091	7.8	8.3	.197	13	7.4	8	3.9	2.09	0.16	9.6	0.48	53
May	.159	4.6	5.0	.110	11	10.3	2	2.1	1.11	0.23	3.9	0.92	46
June	.234	1.2	1.3	.031	8	13.0	0	0.8	0.00	0.97	0.0	2.08	45
July	.273	0.0	0.0	.000	7	14.3	2	1.2	0.27	1.89	3.6	2.78	28
August	.279	0.5	0.1	.001	6	10.5	6	1.8	0.72	2.45	7.0	3.10	0
September	.262	2.1	1.2	.015	4	11.5	7	0.1	1.56	2.24	10.7	2.61	5
October	.211	4.6	3.1	.044	2	9.3	8	0.0	2.96	1.30	17.0	1.33	33
November	.146	7.7	5.7	.096	0	11.2	6	0.4	3.94	0.85	22.6	0.73	55
December	.080	10.5	9.0	.168	3	7.1	12	3.1	5.09	0.63	30.1	0.45	63
Number of years employed	26	10	10	10	10	14	22	13	24	24	24	24	21

TABLE XII.—*Values of the coefficients and constant angles in the periodical expression* $V\lambda = C_1 \sin(\lambda + \alpha) + C_2 \sin(2\lambda + \beta) + C_3 \sin(3\lambda + \gamma) + C_4 \sin(4\lambda + \delta)$ *(in which* $V\lambda$ *is the variation above or below the mean, when the sun's longitude is* λ*; counting* $\lambda = 0$ *on January 0).*

Coefficients and angles. \ Element.	Atmospheric pressure.	Air temperature.	Evaporation temperature.	Vapor tension.	Relative humidity.	Possible sunshine.	Amount of cloud.	Rainfall.	Wind. Components. North.	Wind. Components. East.	Wind. Resultants. Direction.	Wind. Resultants. Velocity.	Direction of upper clouds.
	Inch.	°	°	*Inch.*	*P. ct.*	*P. ct.*	*P. ct.*	*Inches.*	*m. p. h.*	*m. p. h.*	°	*m. p. h.*	°
C_1	0.1399	5.870	5.831	0.1311	5.61	5.44	6.06	3.366	2.291	1.071	12.84	1.450	28.75
C_2	.0045	0.331	0.335	.0148	1.32	2.64	2.90	1.689	0.153	0.383	0.74	0.407	10.35
C_3	.0050	0.306	0.419	.0075	0.71	0.24	0.69	0.380	0.212	0.135	1.63	0.112	7.11
C_4	.0093	0.042	0.072	.0026	0.44	0.39	0.36	0.257	0.061	0.031	0.58	0.050	2.50
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
α	228 15	62 26	51 30	43.9	339.33	229 5	72 42	31.9	87.7	209.28	95 3	230.9	43 26
β	116 49	225 51	276 56	319.19	319.7	148 44	143 25	353.37	183.47	6.16	75 45	25.53	142 7
γ	247 37	120 26	105 5	110.8	90.0	150 58	120 58	187.8	151.26	119.41	152 53	102.43	264 18
δ	136 58	330 3	8 18	20.24	49.6	68 30	98 57	137.0	111.24	87.20	120 0	127.45	90 0

Relation between Fourier coefficients.—The relations between the Fourier coefficients in the several elements are given in Table XIII. In each element the first term of the Fourier series is the most important. In relative humidity, amount of sunshine and cloud, rainfall, east component and velocity of the wind, and direction of the upper clouds the second term is relatively important. In atmospheric pressure, temperature of evaporation, and north component and direction of the wind the coefficient of the third term is greater than in the second; in air temperature they are practically the same, but 24 points on a mathematically smoothed curve of air temperature, at intervals of exactly 15° of solar longitude, gives a greater coefficient for the third term than for the second. In two elements only, atmospheric pressure and sunshine, is the coefficient of the fourth term greater than in the

third or second. Its relatively high value in atmospheric pressure is due principally to well-marked peaks in June and September on the curve of mean daily values from 1875 to 1899. It remains to be seen whether they will disappear when the observations made in Port Louis from 1853 to 1871 are combined with the present series. Judging from the relative values of C_3 and C_4 in the cloud curve, it is probable that with a longer series of observations the ratio C_4/C_3 in the sunshine curve will become inverted.

TABLE XIII.—*Relations between the Fourier Coefficients in Table XI.*

Element.	C_2/C.	C_3/C.	C_4/C.
Atmospheric pressure	0.032	0.036	0.066
Air temperature	.056	.052	.007
Evaporation temperature	.048	.065	.010
Vapor tension	.011	.006	.002
Relative humidity	.235	.127	.078
Sunshine	.403	.044	.092
Amount of cloud	.479	.114	.059
Rainfall	.502	.113	.076
Wind component (N)	.067	.093	.027
Wind component (E)	.358	.126	.029
Wind direction	.058	.127	.045
Wind velocity	.281	.077	.034
Direction of upper cloud	.360	.247	.087

Means and extremes.—The normal means and extremes of the several elements, together with the dates on which they occur, are given in Table XIV. The absolute extremes are given in Table XV.

Description of the curves.—The mean values of atmospheric pressure, temperature of the air and evaporation, and vapor tension occur at nearly the same epoch, though the air temperature reaches its first mean value a week earlier than the other three elements, and its second mean value a fortnight earlier. The rainfall and relative humidity curves are irregular and somewhat similar in character, the phases being about six weeks in advance in the former. The most striking features in the wind curves are two positive waves in the east component in the months of January and April, and one in the north component in the month of March. As the east component is large relatively to the north, the direction curve runs nearly parallel with the latter and the velocity with the former. The velocity reaches its first mean value a fortnight later than the atmospheric pressure, and its second three weeks earlier. The direction reaches its first mean value five weeks earlier, and its second six weeks earlier than the atmospheric pressure. The observed velocity irrespective of direction has a mean value four times a year—on January 5, February 18, June 13, and October 16.

The inverted sunshine curve naturally follows the amount of cloud curve, though the latter passes its minimum a month in advance of the former.

The upper cloud direction has a larger annual inequality than the

surface wind, and reaches its maximum two months later, or about the same time as the east component of the surface wind. The angle which the upper clouds make with the surface winds in each month is given below:

	°		°
January	176	July	158
February	180	August	128
March	184	September	129
April	177	October	150
May	177	November	167
June	180	December	168

The above results depend upon eye observations made at 6^h, 9^h, 13^h, and 15^h, from 1877 to 1897. The varieties included are cirrus, cirro-stratus, and cirro-cumulus, all of which are most prevalent in summer, particularly the first mentioned, which is seldom observed in the winter months. This probably accounts for the largeness of the annual inequality, for not only is the deduced mean direction less accurate in the winter than in the summer, owing to the small number of observations, but probably the mean altitude of the clouds observed is less.

In the month of July during the period 1877 to 1897 the direction of the upper clouds could be determined only on 123 occasions and in August on 135 occasions, of which only a small percentage referred to cirrus, while in December and January the corresponding figures were 377 and 405, with a larger percentage of cirrus.

TABLE XIV.—*Mean and extreme values of the meteorological elements* (*normals*).

Element.	Mean value.		Maximum.		Minimum.	
	Value.	Dates.	Value.	Date.	Value.	Date.
Atmospheric pressure, inches	29.880	May 12–Nov. 14	+ 0.131	Aug. 10	– 0.155	Feb. 8
Air temperature, degrees	73.42	May 6–Oct. 28	+ 5.6	Jan. 20	– 6.0	July 20
Evaporation temperature, degrees	68.57	May 13–Nov. 14	+ 5.5	Feb. 10	– 5.6	July 29
Vapor tension, inches	.623	May 17–Nov. 25	+ .136	Feb. 19	– .120	July 28
Relative humidity, per cent	75.1	Jan. 12–Aug. 11	+ 5.6	Apr. 5	– 6.9	Nov. 14
Possible sunshine, per cent	63.7	Apr. 20–Dec. 12	+ 5.9	July 10	– 8.5	Mar. 11
Clear sky, per cent	43.1	Apr. 15–Dec. 7	+ 7.9	June 15	– 7.1	Mar. 10
Wind component (north), miles per hour	2.53	Apr. 7–Oct. 3	+ 2.95	Dec. 24	– 2.64	June 18
Wind component (east), miles per hour	8.85	June 15–Nov. 4	+ 1.60	Aug. 29	– 1.00	Mar. 8
Resultant velocity, miles per hour	9.20	May 25–Oct. 23	+ 2.03	Aug. 20	– 1.22	Mar. 4
	° ′		° ′		° ′	
Resultant direction	74 2	Apr. 2–Sept. 29	+18 48	Dec. 24	– 14 5	June 18
Direction of upper cloud, degrees	21 9	Apr. 13–Nov. 15	+55	Aug. 20	– 14	Mar. 10

TABLE XV.—*Absolute maxima and minima of the meteorological elements.*

Element.	Absolute maximum.	Absolute minimum.
Atmospheric pressure, inches	30.276 on June 30, 1877	27.767 on Apr. 29, 1892.
Air temperature, degrees	94.7 on Dec. 23, 1900	50.8 on June 29, 1900.
Evaporation temperature, degrees	81.3 on Feb. 21, 1900	48.9 on June 10, 1894.
Vapor tension, inches	0.994 on Jan. 14, 1897	0.321 on June 10, 1894.
Relative humidity, per cent	98.5 on Jan. 12, 1901	31.0 on Nov. 26, 1896.
Recorded velocity of the wind, miles per hour	103.3 on Apr. 29, 1892	

DIURNAL INEQUALITY—HARMONIC ANALYSIS

Diurnal inequality.—In Table XVI is given the diurnal inequality of the meteorological elements and the number of years employed in each element. The baromèter and wind results are practically final, but a longer series of observations in the other elements is necessary. The amount of cloud has only been observed at each hour of the day since 1903, November. The values given are therefore only approximate.

TABLE XVI.—*Diurnal inequality (each element is diminished by the smallest hourly value).*

Element. / Hour.	Atmospheric pressure.	Temperature. Air.	Temperature. Evaporation.	Vapor tension.	Relative humidity.	Rainfall.	Amount of cloud.	Wind. Components. North.	Wind. Components. East.	Wind. Resultants. Direction.	Wind. Resultants. Velocity.
	In.	°	°	*Inch.*	*Per ct.*	*Inch.*	*Per cent.*	*m. p. h.*	*m. p. h.*	° ′	*m. p. h.*
0^h	0.055	1.2	0.9	0.013	23.6	0.029	0.0	0.30	0.34	2 46	0.24
1^h	.045	.9	.7	.012	24.2	.048	4.5	.27	.23	2 13	.15
2^h	.032	.6	.5	.008	24.8	.062	4.8	.22	.12	1 30	.07
3^h	.025	.3	.3	.005	25.1	.074	4.9	.18	.03	59	.00
4^h	.021	.1	.2	.003	25.4	.046	5.7	.12	.00	22	.00
5^h	.026	.0	.0	.000	25.6	.045	9.9	.05	.04	00	.06
6^h	.037	.2	.2	.004	25.5	.047	12.0	.00	.26	23	.28
7^h	.050	2.4	1.6	.023	21.6	.038	11.7	.01	1.04	2 47	.99
8^h	.061	5.9	3.3	.033	13.8	.032	16.5	.25	3.10	8 38	2.96
9^h	.069	8.1	3.9	.023	7.4	.011	21.8	.60	4.02	13 00	4.63
10^h	.065	9.6	4.4	.029	3.5	.023	23.5	1.09	6.03	16 90	5.53
11^h	.055	10.4	4.5	.014	1.3	.041	25.7	1.57	6.18	18 24	5.61
Noon	.037	11.0	4.7	.015	.3	.042	24.5	1.84	6.02	19 33	5.42
13^h	.021	11.0	4.7	.012	.0	.038	27.2	1.73	5.82	18 56	5.23
14^h	.006	10.8	4.6	.012	.5	.056	27.1	1.51	5.60	17 47	5.04
15^h	.000	10.0	4.3	.010	1.8	.041	25.9	1.07	5.26	15 28	4.77
16^h	.001	9.0	3.9	.011	3.9	.008	23.5	.56	4.80	12 34	4.42
17^h	.010	7.5	3.4	.013	7.4	.000	18.9	.39	3.87	10 33	3.56
18^h	.023	5.5	2.8	.018	12.8	.012	19.8	.37	2.08	7 29	1.84
19^h	.040	4.0	2.3	.022	17.2	.001	11.1	.36	1.08	5 13	.90
20^h	.055	3.1	1.9	.021	19.5	.001	3.2	.34	.76	4 15	.61
21^h	.066	2.5	1.5	.019	21.0	.021	1.3	.33	.62	3 48	.48
22^h	.068	2.0	1.3	.017	22.0	.037	4.0	.33	.52	3 31	.39
23^h	.065	1.6	1.1	.014	22.8	.036	4.3	.32	.43	3 11	.31
Years employed...	25	9	9	9	9	10	0.75	24	24	24	24

Harmonic analysis.—The results of harmonic analysis of the diurnal inequality of the several elements are given in Table XVII. In order to shorten the computations only alternate hours have been used.

TABLE XVII.—*Values of the coefficients and constant angles in the periodical expression* $V_t = C_1 \sin(t+\alpha) + C_2 \sin(2t+\beta) + C_3 \sin(3t+\gamma) + C_4 \sin(4t+\delta)$.

[In which V_t is the variation above or below the mean at the time t; counting from Mauritius mean midnight.]

Element. / Coefficients and angles.	Atmospheric pressure.	Temperature. Air.	Temperature. Evaporation.	Vapor tension.	Relative humidity.	Amount of cloud.	Rainfall.	Wind. Components. North.	Wind. Components. East.	Wind. Resultants. Direction.	Wind. Resultants. Velocity.
	Inches.	°	°	*Inches.*	*Per ct.*	*Per cent.*	*Inches.*	*m. p. h.*	*m. p. h.*	°	*m. p. h.*
C_1	0.01161	5.581	2.240	0.00262	13.35	12.48	0.0150	0.604	3.154	8.70	2.89
C_2	.02865	1.444	.567	.00771	3.53	2.60	.0176	.453	.944	3.50	.82
C_3	.00201	.514	.300	.00316	1.64	1.17	.0073	.185	.499	.71	.62
C_4	.00067	.376	.148	.00407	1.20	.67	.0051	.038	.456	.67	.43
	° ′										
α	45 49	246.26	247.0	222.46	67.58	261.39	4.53	251.12	257.3	251.21	257.52
β	162 25	74.50	109.44	186.29	259.6	33.40	23.42	80.41	86.24	87.0	86.13
γ	20 33	31.52	41.49	63.26	201.3	45.0	193.8	264.9	12.0	354.17	33.39
δ	270 0	242.32	287.0	352.57	43.54	150.0	284.48	150.0	215.38	214.57	215.10

Relation between Fourier coefficients.—The relations between the Fourier coefficients in the several elements are given in Table XVIII. The first term of the Fourier series is the most important in each element, except atmospheric pressure, vapor tension, and rainfall, in each of which the second term is of greater importance than the first. In vapor tension the coefficient C is less than either C_2, C_3, or C_4. The second term is relatively important in the north component of the wind and, in a less degree, in wind direction.

It should be mentioned that in the foregoing analysis of annual and diurnal inequalities, where only monthly or alternate hourly values have been used, the results are only approximate. As instances of the different results obtained by using different points on the curve the formula for the annual inequality of evaporation temperature is given A, as derived from monthly means of the daily normals, and B, as derived from 24 equidistant points on the hand-smoothed annual curve.

A. $5.767° \sin(\lambda + 51° 10') + 0.278° \sin(2\lambda + 291° 3') + 0.373° \sin(3\lambda + 108° 26') + 0.060° \sin(4\lambda + 16° 6')$.

B. $5.831° \sin(\lambda + 51° 30') + 0.335° \sin(2\lambda + 276° 56') + 0.419° \sin(3\lambda + 105° 5') + 0.072° \sin(4\lambda + 18° 18')$.

The difference arises from the facts that the mean value of an element for any month does not lie exactly on the annual curve except when the curve is sensibly linear throughout that month, and that 12 values are not sufficient for an accurate analysis of the curve. Also the mean monthly values do not represent exactly equidistant points as regards time, but the resulting error from this source is small.

TABLE XVIII.—*Relations between the Fourier coefficients in Table XVI.*

Element.	C_2/C_1.	C_3/C_1.	$C_4 C_1$.
Atmospheric pressure	2.47	0.173	0.058
Air temperature	.259	.092	.067
Evaporation temperature	.253	.134	.066
Vapor tension	2.94	1.21	1.55
Relative humidity	.264	.123	.090
Amount of cloud	.208	.094	.054
Rainfall	1.13	.487	.340
Wind component (N)	.750	.306	.063
Wind component (E)	.300	.158	.145
Wind direction	.402	.082	.077
Wind velocity	.281	.215	.149

Means and extremes.—The time of day at which, on the average for the year, the maximum, minimum, and mean values of the several meteorological elements occur is given in Table XIX.

Table XIX.—Maximum, minimum, and mean values of the several meteorological elements, with time of occurrence.

Element.	Maximum. Value.	Maximum. Hour (M.C.T.).	Minimum. Value.	Minimum. Hour (M.C.T.).	Mean. Value.	Mean. Hour (M.C.T.).	Mean. Hour (M.C.T.).
	In.	*h. m.*	*In.*	*h. m.*		*h. m.*	*h. m.*
Atmospheric pressure	+ 0.030	9 10	– 0.039	15 15	29.880	11 55	18 55
	+ .029	21 50	– .018	3 50	29.880	1 25	6 10
	°		°		°		
Air temperature	+ 6.3	12 40	– 5.0	5 50	73.42	7 45	18 25
Evaporation temperature	+ 2.3	13 0	– 2.4	5 20	68.57	7 25	18 55
	In.		*In.*		*In.*		
Vapor tension	+ 0.019	8 0	0.014	5 5	0.623	6 30	11 10
	+ .008	19 5	– .005	15 20	.623	17 10	23 0
	Per ct.		*Per ct.*		*Per ct.*		
Relative humidity	+ 12.5	5 15	– 19.5	12 40	75.1	7 55	18 25
Amount of cloud	+ 13.5	13 20	– 15.5	20 50	56.9	7 30	18 20
Amount of sunshine	+ 14.3	10 20	....	....	63.7	7 20	16 0
	In.		*In.*		*In.*		
Rainfall	+ 0.042	3 30	– 0.035	20 0	0.180	0 50	8 10
	+ .023	14 30	– .023	9 40	.180	10 55	15 40
	m. p. h.		*m. p. h.*		*m. p. h.*		
Wind component (N)	+ 1.27	12 10	– 0.064	6 10	– 2.53	8 50	15 55
Wind component (E)	+ 3.75	10 40	– 2.46	4 0	8.85	7 45	17 50
	°		°		°		
Wind direction	+ 10.2	12 10	– 9.3	5 50	74.2	8 10	17 25
	m. p. h.		*m. p. h.*		*m. p. h.*		
Wind velocity	+ 3.53	10 40	– 2.20	3 30	9.20	7 40	17 50
Recorded wind velocity irrespective of direction	+ 4.82	12 40	– 2.90	4 0	11.15	7 55	17 50

Description of diurnal inequalities.—The curve of atmospheric pressure is a regular double wave. From the 9 a. m. maximum o the 3 p. m. minimum the range is 0.069 inch, and from that to the 10 p. m. maximum is 0.068 inch; from that to the 4 a. m. minimum is 0.047 inch, and from that to the 9 a. m. maximum is 0.048 inch.

The curve of vapor tension shows a very remarkable rise from 5 a. m. to 8 a. m., followed by a more gradual descent until 3 p. m. A secondary maximum occurs at 7 p. m. The rainfall curve is very irregular and its character varies in different seasons of the year. The double oscillation is most marked in January and February; with a longer series of observations, however, it may be well shown in the other months also. The curves of air and evaporation temperatures, relative humidity (inverted), amount of cloud, wind components and resultants are generally similar in character. The range of evaporation temperature is less than one-half of the air-temperature range. Its minimum and first mean value occur from twenty to thirty minutes earlier, and its maximum and second mean value from twenty to thirty minutes later than in air temperature. The phases of the (inverted) relative humidity curve are nearly synchronous with those of the air-temperature curve, except that the maximum relative humidity occurs at 5.15 a. m., whereas the minimum air temperature occurs at 5.50 a. m.

The cloud curve is very regular, considering the short period of observation (nine months). There are, however, curious negative waves at 0^h, 7^h, 12^h, 18^h, and 21^h to 22^h. The first four may be due to personality among the observers. The observations at noon and midnight are made by one of three junior assistants in daily rotation, and at 7^h by the telegraph clerk; from 8^h to 11^h and 13^h to 16^h they are made by a senior assistant, and from 17^h to 23^h and 1^h to 6^h by the night watchman, who records the exact time of the observations on the drum of the Dines anemometer by putting the recording pen to zero.

Assuming that the above-mentioned waves are due to personality, it would appear that (the mean of) the three junior assistants' estimate is 2 per cent lower and that of the night watchman 3 per cent higher than the senior assistant. Correcting for this assumed personality the curve becomes smoother though there is still a marked negative wave culminating at 21^h. There is also a very slight positive wave culminating at $5\frac{1}{2}^h$. It remains to be seen whether they will be eliminated when a longer series of observations is available and the personal equation of the several observers determined. It is probable that the latter will vary with varying amounts of cloud.

As regards the connection between the cloud and sunshine curves there are several points of interest to be considered. The percentage of possible sunshine increases rapidly from shortly after sunrise, attains a maximum between 10^h and 11^h, and then decreases slowly until about 16^h, but with increasing rapidity afterwards.

The cloud curve shows variations corresponding nearly to the variations in the sunshine curve, from 10^h to 14^h; but farther from the meridian than this the sun's altitude has a greater effect than the cloud variations on the amount of sunshine recorded.

The mean percentage of possible sunshine during the day, from 1877 to 1899, and of clear sky from 1903, November, to 1904, July, is as follows:

Epoch.	$6^h.6$	$7^h.5$	$8^h.5$	$9^h.5$	$10^h.5$	$11^h.5$	$12^h.5$	$13^h.5$	$14^h.5$	$15^h.5$	$16^h.5$	$17^h.4$
Percentage of possible sunshine	29.5	65.0	73.8	76.7	77.5	76.2	75.3	72.7	69.8	66.5	59.9	30.1
Percentage of clear sky	50.3	48.0	43.0	39.5	37.5	36.0	35.2	35.0	35.6	37.4	40.9	42.8

Allowing for the variation in the amount of clear sky on the assumption, for the present, that the amount of sunshine varies directly with it, we obtain the following results for a uniform amount of cloud:

Epoch.	$6^h.6$	$7^h.5$	$8^h.5$	$9^h.5$	$10^h.5$	$11^h.5$	$12^h.5$	$13^h.5$	$14^h.5$	$15^h.5$	$16^h.5$	$17^h.4$
Corrected percentage of possible sunshine	15.2	53.0	66.8	73.2	76.0	76.2	76.1	73.7	70.2	65.1	55.0	23.3

The figures are still unsymmetrical with respect to noon, each of the four hours preceding showing an excess of sunshine over the corresponding hours following noon, and the fifth and sixth hours preceding showing a defect.

The excess of the forenoon hours are as follows:

Hours ending—	Excess of morning hours.	Hours ending—	Excess of morning hours.
	Per cent.		*Per cent.*
12^h to 13^h ..	+0.1	9^h to 16^h	+1.7
11^h to 14^h ..	+2.3	8^h to 17^h	−2.0
10^h to 15^h ..	+3.0	7^h to 18^h	−8.1

In order to see whether this result was due to the fact that the observation periods for sunshine and cloud were not identical, the sunshine records for the period during which hourly cloud observations are available have been examined. The results show that during the winter months, from May to August, the sunshine curve, after correction for varying amounts of cloud, is nearly symmetrical with respect to noon up to an hour angle of four hours, the excess of the morning hours in the winter being as follows:

Hours ending—	Excess of morning hours.	Hours ending—	Excess of morning hours.
	Per cent.		*Per cent.*
12^h to 13^h ..	+1.0	9^h to 16^h	− 0.4
11^h to 14^h ..	− .6	8^h to 17^h	−11.3
10^h to 15^h ..	.9		

But in the summer months, from November to February, the excess of the forenoon hours is very strongly marked, as shown below:

Hours ending—	Excess of morning hours	Hours ending—	Excess of morning hours.
	Per cent.		*Per cent.*
12^h to 13^h ..	+5.8	9^h to 16^h	+7.8
11^h to 14^h ..	+7.8	8^h to 17^h	+3.5
10^h to 15^h ..	+6.9	7^h to 18^h	−5.7

This difference between the summer and winter results suggested the following explanation of the want of symmetry in the sunshine curve during the summer months: Thin upper cloud is more prevalent in the summer than in the winter, and in the Tropics the sun frequently burns the registering paper when shining through thin cloud, and more frequently in summer than in winter; so that if the total amount of cloud comprises more of this variety in the forenoon than in the afternoon, the amount of sunshine registered, with the same total amount of cloud, will be greater before than after noon.

At 6^h, 9^h, 13^h, and 15^h the amounts of upper and lower clouds are

observed separately, the former comprising all varieties above the altitude of cirro-cumulus. The mean amount of upper cloud at 9^h, 13^h, and 15^h in the months of November to February from 1887 to 1899, on a scale of 0–100, are as follows:

Amount of upper cloud.

9^h	9.5
13^h	8.5
15^h	10.8

That is to say, the amount of upper cloud in the summer months is 1.3 per cent greater at 15^h than at 9^h, and therefore the observed excess of sunshine in the forenoon hours, after correction for variations in the total amount of cloud, is not due to excess of upper cloud at these hours; and we are forced to the somewhat interesting conclusion that in the summer months the neighborhood of the sun is more cloudy, relatively to the remainder of the sky, in the five hours following than in the five hours preceding noon.

The observed diurnal inequality in the amount of cloud indicates a broken layer of cloud traveling round the earth with its point of maximum density toward, but lagging (in the summer months) about two and one-half hours behind the sun. The latter, being so much farther from the earth than the former, will appear to an observer at Mauritius (in the summer months) to cross the point of maximum density of the cloud layer soon after 2.30 p. m. (apparent time), thus giving rise to the observed defect of sunshine in the afternoon hours.

In the winter, though the diurnal inequality in the amount of cloud is even greater than in summer, the lagging behind the sun amounts to less than one hour; hence, we should expect a more symmetrical curve of sunshine in winter than in summer, with slightly more sunshine (after correction for the difference in the observed amount of cloud), and this is borne out by the observations during the three available months. Slightly more sunshine might also be expected in the hour ending 11^h than in the hour ending 14^h, but from accidental irregularities in cloud or sunshine, or both, which in so short a period have not been eliminated, this is not shown in the results.

In the wind curves the most striking feature is the want of symmetry, with respect to noon, in the east component, which, during the daylight hours, closely resembles the sunshine curve. It increases rapidly from 7^h to its maximum at $10^h\ 40^m$, and then decreases slowly until 16^h, but afterwards more rapidly until 19^h, when the decrease becomes more gradual. The same characteristics occur in the resultant velocity curve, the east component being so much greater than the north. The latter is nearly symmetrical with respect to noon from 8^h to 16^h, though the maximum occurs at about $12^h\ 40^m$. The decrease from 16^h to the minimum (at $6^h\ 10^m$) is very gradual, but as the east

component decreases rapidly from 16^h to 19^h, the wind-direction curve, which otherwise follows closely the north component, continues to fall steadily until 19^h, and similarly it commences to rise earlier than the north component. The curve of velocity, as recorded by the Robinson anemometer, irrespective of direction, is nearly symmetrical with respect to noon, and reaches its maximum at 12^h 40^m, following very closely the curve of air temperature, though its minimum is reached nearly two hours earlier than the latter.

LONG-PERIOD VARIATIONS

In a paper read before the Meteorological Society of Mauritius on October 23, 1902, it was shown that in each of the meteorological elements long-period waves occur with small superposed fluctuations, the mean interval between two successive crests being about 2.3 years. These waves, though well marked in each element, are most regular in the temperature abnormality curve. Within certain rather wide limits maximum pressure coincides with maximum wind velocity and minimum temperature, and vice versa.

If an increase of pressure always indicated a steeper gradient over Mauritius, and vice versa, the above result would always be observed. But the normal gradient over Mauritius being from south to north, a plus pulse will produce a steeper gradient only when the "center of action" of the pulse is to the south of Mauritius. This is usually the case. It occasionally happens, however, that the "center of action" is to the north, a negative pulse will then produce a steeper gradient, and when it is situated in about the same latitude as Mauritius, positive and negative pulses will have very little effect on the gradient; hence the occasional departure from the above law.

The connection between the pressure and rainfall variations is less obvious, although in the long run their periods are sensibly equal. Positive and negative waves of pressure appear to be accompanied indiscriminately by either floods or droughts, and though there have been striking examples of a connection in one direction there have been equally striking examples of a connection in the opposite sense.

TABLE XX.—*Quarterly variations above or below normal.*

Element	Atmospheric pressure.				Air temperature.				Wind velocity.				Rainfall.			
Year	Jan.-Mar.	Apr.-June.	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June.	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June.	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June.	July-Sept.	Oct.-Dec.
	Ins.	*Ins.*	*Ins.*	*Ins.*	°	°	°	°	*m. p. h.*	*m. p. h.*	*m. p. h.*	*m. p. h.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1875	+0.021	0.012	0.019	0.013	1.8	1.5	−0.8	−2.1	....	....	....	....	−60	−26	−39	−105
1876	[illegible]	.020	.023	.013	.8	.2	.1	−1.5	1.7	−1.5	−2.0	−1.3	− 7	−24	−21	2
1877	.009	.021	.025	.006	1.1	.9	1.5	+ .7	− .2	+2.2	−2.7	+ .5	−53	+26	−12	42
1878	.022	.020	.006	.039	2.6	1.6	− .9	− .9	− .4	−1.8	− .3	+1.1	−24	+15	−20	34
1879	.002	.011	.021	.021	+ .3	.0	− .1	− .1	−2.2	.0	− .8	+1.1	−12	−14	−34	−25
1880	.016	.004	.025	.047	.3	.4	.4	.8	−2.6	+ .5	+1.0	−2.1	−25	−20	−23	−42
1881	.014	.003	.015	.009	.5	.7	− .3	− .2	+ .4	− .2	+ .4	−1.3	−52	+22	+ 1	+ 7
1882	.020	.013	.009	.003	.3	.8	+ .9	1.0	+ .2	− .7	− .7	− .2	+73	−37	+43	−21
1883	.021	.020	.004	.010	.4	1.0	.6	.3	− .2	− .3	− .1	− .2	−11	+32	−28	+ 5
1884	.010	.024	.032	.004	.6	.4	.1	− .4	−1.3	− .3	−2.1	− .3	−26	+20	−36	− 9
1885	.005	.004	.004	.000	+ .1	− .4	− .7	− .7	−1.8	− .9	− .8	+ .4	−40	+39	+ 9	−11
1886	.011	.003	.019	.013	.9	.3	− .5	−1.0	− .7	−2.1	− .4	− .1	−53	30	−41	−27
1887	.012	.022	.003	.023	1.0	1.2	−1.4	1.0	− .6	−1.4	− .7	+ .8	+15	−13	16	− 2
1888	+ .020	+ .022	.013	.001	1.0	.6	.0	+ .1	− .8	−1.0	−1.1	−1.2	+49	−23	− 1	+80
1889	+ .050	.011	.000	.015	.6	.4	.2	−1.0	+ .2	−1.3	− .6	− .9	+65	−41	− 5	−21
1890	+ .024	.017	.007	.010	1.3	1.7	1.6	−1.1	−2.3	−1.6	−1.4	−1.6	− 2	+ 2	−15	3
1891	− .001	.022	.023	.011	1.0	.5	.6	+ .2	− .3	−1.3	−1.1	−1.3	− 6	+ 8	+34	+ 3
1892	.032	.024	.012	.007	.4	+1.3	+ .4	− .2	− .6	+ .1	+ .6	−1.2	+23	+ 2	+10	− 2
1893	.023	.013	+ .029	.019	.8	1.2	−1.3	−1.2	− .8	1.0	− .2	− .5	− 7	+23	−26	39
1894	.010	.005	.020	.025	.5	1.5	+ .3	+ .1	1.7	1.3	− .2	+ .2	− 1	−21	+19	−13
1895	.022	.004	.014	.006	+ .4	+ .1	+ .3	.0	+ .4	+ .6	− .8	− .3	0	+ 2	+11	+26
1896	.000	.003	.032	.019	.7	.1	.9	+ .2	+ .2	− .2	− .4	− .3	+49	+72	28	−48
1897	.008	+ .017	.002	.022	.3	.3	− .8	+1.1	.7	+1.5	−1.6	− .1	−28	30	24	− 5
1898	.000	.017	.028	.026	+ .1	.1	− .2	− .1	−1.0	+1.9	− .1	−1.0	−18	−10	+31	−54
1899	.019	+ .009	+ .052	+ .014	+ .1	.3	− .2	.0	+ .1	− .5	+1.1	−1.2	+ 2	− 7	+27	−35
1900	.034	.031	.022	+ .018	+ .5	+ .4	−1.0	− .3	−2.4	−1.0	−1.7	− .6	−24	−29	38	−51
1901	.021	.009	+ .018	+ .028	.1	.9	.5	.0	−1.1	+ .2	− .2	+ .1	+15	−12	7	+37
1902	.012	.017	.038	.038	− .8	+ .2	+1.1	+1.0	+1.1	−2.4	−1.7	− .9	−15	−29	−21	+61
1903	.042	.018	.011	+ .008	− .7	+ .4	.0	−1.5	−2.2	− .7	.0	+ .3	−13	−12	−32	−32
1904	.000	.021	....	....	.5	−1.0	....	....	+ .5	−1.9	....	....	−13	+12	−40	....

TABLE XXI.—*Epochs of maxima and minima.*

Epoch of maximum.				Epoch of minimum.				Intervals.							
								Atmospheric pressure.		Wind velocity.		Temperature (inverted).		Rainfall.	
Atmospheric pressure.	Wind velocity.	Temperature (inverted).	Rainfall.	Atmospheric pressure.	Wind velocity.	Temperature (inverted).	Rainfall.	Maximum to minimum.	Minimum to maximum.	Maximum to minimum.	Minimum to maximum.	Maximum to minimum.	Minimum to maximum.	Maximum to minimum.	Minimum to maximum.
				1875.7		1875.8	1876.3								
1876.8	1877.3	1876.6	1877.2	1878.6	1878.7	1878.3	1878.7	1.9	1.0	1.4	....	1.7	0.8	1.5	0.9
1879.3	1879.2	1879.3	1879.5	1879.9	1879.8	1879.9	1880.4	0.6	1.7	0.6	0.5	0.6	1.0	0.9	0.8
1880.8	1880.8	1880.8	1881.7	1882.8	1882.7	1882.9	1883.8	2.0	0.9	1.9	1.0	2.1	0.9	2.1	1.3
1883.9	1883.9	1884.2	1884.9	1884.8	1884.9	1885.3	1886.0	0.9	1.1	1.0	1.2	1.1	1.3	1.1	1.1
1885.7	1885.9	1885.9	1886.9	1886.4	1886.9	1886.6	1887.7	0.7	0.9	1.0	1.0	0.7	0.6	0.8	0.9
1887.0	1887.7	1887.4	1888.0	1888.0	1888.7	1888.7	1888.7	1.0	0.6	1.0	0.8	1.3	0.8	0.7	0.3
1889.2	1889.5	1889.2	1889.2	1890.4	1890.4	1889.9	1890.1	1.2	1.2	0.9	0.8	0.7	0.5	0.9	0.5
1891.5	1892.2	1890.9	1891.8	1892.7	1893.2	1892.6	1893.5	1.2	1.1	1.0	1.8	1.7	1.0	0.7	1.7
1893.5	1894.2	1849.8	1894.4	1894.9	1895.6	1895.3	1895.3	1.4	0.8	1.4	1.0	1.5	1.2	0.9	0.9
1896.8	1897.4	1896.7	1896.4	1898.7	1898.7	1898.0	1897.9	1.9	1.9	1.3	1.8	1.3	1.4	1.5	1.1
1899.7	1899.7	1899.5	1899.5	1900.4	1900.4	1900.4	1900.8	0.7	1.0	0.7	1.0	0.9	1.5	1.3	1.6
1901.2	1901.6	1901.6	1901.9	1902.9	1902.9	1902.9	1903.8	1.7	0.8	1.3	1.2	1.3	1.2	1.9	1.1
1904.7(?)	1901.3(?)	1901.3(?)	1905.0(?)	....	....	....	....	....	1.8	....	1.4	....	1.4	....	1.2
Mean........	....	....	....	....	....	....	....	1.27	1.14	1.12	1.12	1.24	1.05	1.19	1.05

In Table XXI are given the epochs of maxima and minima of atmospheric pressure, air temperature, wind velocity, and rainfall, as read off from a hand smoothed curve of quarterly departures, together with the intervals from successive maxima to minima and minima to maxima. The mean interval from maximum to minimum atmospheric pressure is 1.27 per year and from minimum to maximum 1.14 per year; but this difference appears to have no real significance, as the former interval was in excess on six occasions and in defect on four occasions. The intervals for the other three elements are sensibly the same as for atmospheric pressure.

Mauritius has just emerged from one of the most remarkable long-period waves on record, particulars of which are given in the following table:

TABLE XXII.—*Monthly departure from average of atmospheric pressure, air temperature, and wind velocity, March, 1902, to September, 1903.*

Month.	Atmospheric pressure.	Air temperature.	Wind velocity.
1902.	*Inch.*	°	*m. p. h.*
March	....	....	– 1.1
April	....	....	– 4.2
May	–0.009	+ 0.3	– 1.4
June	– .045	+ 1.8	– 1.5
July	.045	+ 1.3	– 1.5
August	– .052	+ 1.3	– 2.5
September	– .017	+ 1.2	– 1.1
October	– .025	+ 1.4	– .4
November	.029	+ 1.4	– 1.8
December	– .090	+ .1	– .4
1903.			
January	.053	+ .2	– 2.7
February	– .015	+ .4	– 3.6
March	.059	+ 1.6	– .3
April	.015	.0	– .2
May	+ .003	+ .1	– 1.0
June	– .037	+ 1.1	– .9
July	.015	+ .5	– 1.1
August	– .011	+ .4	....
September	.005	....	....
Sums	.519	+13.1	–25.7

The pressure and temperature waves are remarkably regular, though the symmetry of the wind-velocity curve is broken in March, October, and December, 1902.

Other large negative waves of pressure occurred as follows:

	Inch.		Inch
May, 1875, to February, 1876 ..	–0.438	January, 1894, to October, 1895.	–0.412
April, 1878, to December, 1878 .	.345	November, 1897, to March, 1899.	– .346
February, 1882, to June, 1883 ..	– .267		

During each of these waves the corresponding positive wave in emperature is well marked, though the epochs of maximum are only approximately coincident. As regards corresponding negative waves

in the wind-velocity curve, during the first pressure wave there are no records of wind velocity. During the second and third waves, though corresponding negative waves of wind velocity are shown on the curve, they do not appear as negative departures from average in Table XX for reasons to be dealt with later. During the fourth wave the wind-velocity curve is irregular and does not follow the pressure curve. During the fifth wave an otherwise well-marked negative wave of wind velocity was broken by large positive values in April and May, 1898.

In addition to the two and one-fourth year period, there are others of longer duration.

Tabulating the annual departures from average in series of sunspot cycles, we obtain the results given in Table XXIII.

Table XXIII.—*Departure from average of the meteorological elements during the sunspot activity cycle.*

ATMOSPHERIC PRESSURE.

Year of minimum solar activity.	Years before or after the epoch of minimum solar activity.										
	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5
	Inch.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1878........	....	....	−0.013	−0.004	+0.008	−0.023	−0.007	+0.031	+0.013	−0.010	−0.014
1889........	−0.012	−0.001	+ .008	+ .015	+ .014	+ .020	+ .002	+ .019	− .015	+ .009	− .022
1901........	+ .014	− .004	− .018	+ .014	+ .018	+ .015	− .020	− .016	....	....	....
Inequality	+ .001	− .001	− .008	+ .008	+ .013	+ .004	− .008	+ .011	− .001	.000	− .018

AIR TEMPERATURE.

	°	°	°	°	°	°	°	°	°	°	°
1878........	....	....	+1.5	+0.6	+1.0	+1.5	+0.1	0.3	+0.2	+0.6	+0.4
1889........	−0.4	+0.1	− .1	−1.1	− .4	− .5	−1.4	.5	+ .5	−1.1	− .4
1901........	− .4	+ .5	− .1	− .1	− .1	− .3	+ .4	− .1	....	....	....
Inequality	− .4	+ .3	+ .4	− .2	+ .2	+ .2	− .3	.3	+ .3	.2	.0

WIND VELOCITY.

	m.p.h.	*m.p.h.*	*m.p.h.*	*m.p.h.*	*m.p.h.*	*m.p.h.*	*m.p.h.*	*m.p.h.*	*m.p.h.*	*m.p.h.*	*m.p.h.*
1878........	....	....	....	+1.6	+1.3	+0.5	+1.0	+1.5	+0.5	+0.1	−0.1
1889........	−1.0	0.8	+0.2	.5	−1.0	.6	1.7	−1.0	− .3	− .6	+ .1
1901........	− .2	+ .9	.1	− .1	−1.4	− .2	−1.0	.6	....	....	....
Inequality	− .6	+ .1	.1	+ .3	− .4	.1	.6	.0	+ .1	.3	.0

RAINFALL.

	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1878........	+18	+26	+ 3	10	+39	4	8	30	13	24	+2
1889........	−15	13	−42	5	+32	+17	3	+ 3	11	− 8	2
1901........	+22	27	− 5	− 8	31	8	1	22	20	....	....
Inequality	+ 8	− 5	15	8	+13	+ 7	−4	− 16	7	8	0

nce can be placed in the mean values for any par- cle. The most that can be said at present is that effect is to increase the pressure shortly before um, and to decrease it at the epoch of maximum being (from the experience of three cycles) from 70 inch. The effect is modified and sometimes not well understood, and of apparently an erratic

mperature the elimination of the two and one-fourth ;t reveals a very remarkable wave of about thirty will be seen from the following table:

XVI.—*Departure from average of air temperature.*

e maxima of temperature).	Mean departure from average.	Corresponding mean epoch.	Years before or after sun-spot minimum.
....	-1.12	1878.0	1.0
....	.05	1880.0	+1.0
....	+ .30	1882.5	+3.5
....	.09	1885.0	+6.0
....	.36	1886.2	-3.3
....	.68	1888.3	-1.2
....	.99	1890.1	+ .6
....	.33	1892.4	+2.9
....	.31	1895.2	+5.7
....	+ .14	1898.1	-3.7
....	.21	1900.5	-1.3
....	- .06	1902.9	+1.1

hat the temperature decreased generally from 1878 ate of 0 .174 per annum, and then increased until of 0 .073 per annum. Allowing for these varia- ogressive changes, we obtain the following results:

—*Values in Table XXVI corrected for progressive change.*

	Departure from average.	Position in sun spot cycle.	Epoch.	Departure from average.	Position in sun-spot cycle.
		Years.		°	*Years.*
...	0.00	1.0	1890.1	0.00	+0.6
...	.81	1.0	1892.4	.48	+2.9
...	.03	+3.5	1895.2	+ .31	+5.7
...	.01	6.0	1898.1	+ .55	-3.7
...	.05	3.3	1900.5	+ .02	1.3
...	.00	1.2	1902.9	.00	+1.1

roduces a practically uniform temperature from om 1892 to 1898, with a difference of 0.46 between ure for the two periods. The inequality obtained values according to their position in the sunspot from this difference and the low temperature from Rejecting the value for this period and making the

It will be seen that, if not entirely masked, the sun-spot activity effect is considerably modified by other periodic and nonperiodic effects. In atmospheric pressure the largest of these is the two and one-fourth year periodic effect, and this may be eliminated by using the mean departure from average for the intervals between successive maxima and minima as given in Table XXI. The results are shown in Table XXIV.

TABLE XXIV.—*Departure from average of atmospheric pressure.*

Period (successive maxima of pressure).	Mean departure from average.	Corresponding mean epoch.	Years before or after sun-spot minimum.
	Inch.		
1878.8 to 1879.3	0.0036	1878.0	-1.0
1879.3 to 1880.8	+ .0055	1880.0	+1.0
1880.8 to 1883.9	+ .0009	1882.3	+3.3
1883.9 to 1885.7	.0108	1884.8	+5.8
1885.7 to 1887.0	.0043	1886.3	-3.2
1887.0 to 1889.2	+ .0190	1888.1	-1.4
1889.2 to 1891.5	+ .0072	1890.3	+ .8
1891.5 to 1893.5	.0042	1892.5	+3.0
1893.5 to 1896.8	.0032	1895.1	+5.6
1896.8 to 1899.7	.0038	1898.2	-3.6
1899.7 to 1901.2	+ .0246	1900.4	-1.4
1901.2 to 1904.7	.0079	1902.9	+1.1

Grouping according to position in the sun-spot cycle we obtain the following results:

TABLE XXV.—*Grouping values in Table XXII.*

Separate values.		Mean values.		
Year in cycle.	Departure from average.	Year in cycle.	Departure from average.	
	Inch.		*Inch.*	*Inch.*
-3.2	+0.0043	-3.4	+0.0002	+0.0049
-3.6	.0038			
1.0	- .0036			
-1.4	+ .0190	-1.3	+ .0133	+ .0117
-1.4	+ .0246			
+1.0	+ .0055			
+0.8	+ .0072	+1.0	- .0016	- .0101
+1.1	.0079			
+3.3	+ .0009	+3.1	.0016	+ .0031
+3.0	.0042			
+5.8	.0108	+5.7	.0070	- .0046
+5.6	- .0032			

It will be seen that after eliminating the two and one-fourth year periodic effect the values in different sun spot cycles are still very contradictory. In the first group in Table XXV we have one positive and one negative wave, both of moderate size. In the second we have the two largest positive waves of the period and one negative wave. In the third there are two positive and one well-marked negative wave. In the fourth a very small positive and a moderate sized negative wave, and in the fifth two negative waves, one large and one small.

The theoretical probable errors given in the last column of Table

XXV show what reliance can be placed in the mean values for any particular year of the cycle. The most that can be said at present is that the sun-spot activity effect is to increase the pressure shortly before the epoch of minimum, and to decrease it at the epoch of maximum activity; the range being (from the experience of three cycles) from +0.0133 to −0.0070 inch. The effect is modified and sometimes inverted by causes not well understood, and of apparently an erratic nature.

As regards air temperature the elimination of the two and one-fourth year periodic effect reveals a very remarkable wave of about thirty years duration, as will be seen from the following table:

TABLE XXVI.—*Departure from average of air temperature.*

Period (successive maxima of temperature).	Mean departure from average.	Corresponding mean epoch.	Years before or after sun-spot minimum.
	°		
1876.6 to 1879.3	+1.12	1878.0	−1.0
1879.3 to 1808.8	.05	1880.0	+1.0
1880.8 to 1884.2	+ .30	1882.5	+3.5
1884.2 to 1885.9	− .09	1885.0	+6.0
1885.9 to 1887.4	− .36	1886.2	−3.3
1887.4 to 1889.2	− .68	1888.3	−1.2
1889.2 to 1890.9	− .99	1890.1	+ .6
1890.9 to 1893.8	− .33	1892.4	+2.9
1893.8 to 1896.7	.31	1895.2	+5.7
1896.7 to 1899.5	+ .14	1898.1	−3.7
1899.5 to 1901.6	− .21	1900.5	−1.3
1901.6 to 1904.3	− .06	1902.9	+1.1

It will be seen that the temperature decreased generally from 1878 to 1890 at a mean rate of 0°.174 per annum, and then increased until 1903 at a mean rate of 0°.073 per annum. Allowing for these variations as uniform progressive changes, we obtain the following results:

TABLE XXVII.—*Values in Table XXVI corrected for progressive change.*

Epoch.	Departure from average.	Position in sun-spot cycle.	Epoch.	Departure from average.	Position in sun-spot cycle.
	°	*Years.*		°	*Years.*
1878.0	0.00	−1.0	1890.1	0.00	+0.6
1880.0	− .81	+1.0	1892.4	+ .48	+2.9
1882.5	.03	+3.5	1895.2	+ .31	+5.7
1885.0	+ .01	+6.0	1898.1	+ .55	−3.7
1886.2	− .05	3.3	1900.5	+ .02	−1.3
1888.3	.00	−1.2	1902.9	.00	+1.1

The operation produces a practically uniform temperature from 1882 to 1890 and from 1892 to 1898, with a difference of 0.46° between the mean temperature for the two periods. The inequality obtained by grouping the values according to their position in the sunspot cycle arises solely from this difference and the low temperature from 1879.3 to 1880.8. Rejecting the value for this period and making the

first uniform period of the same temperature as the second, i. e., subtracting 0.46° from the variations at 1892.4, 1895.2, and 1898.1, we obtain the following results, which reveal no sunspot activity effect:

TABLE XXVIII.—*Grouping values in Table XXVII.*

Separate values.		Mean values.	
Year in cycle.	Departure from average.	Year in cycle.	Departure from average.
	°		° °
−3.3	−0.05	−3.5	+0.02 ± 0.08
−3.7	+ .09		
−1.0	.00	1.2	+ .01 ± .01
−1.2	.00		
−1.3	+ .02		
+ .6	.00	+ .9	.00 ± .00
+1.1	.00		
+6.0	+ .01	+5.8	− .07 ± .10
+5.7	− .15		

The departure from average of wind velocity, after eliminating the 2¼-year periodic effect is given in Table XXIX.

TABLE XXIX.—*Departure from average of wind velocity.*

Period (successive maxima of velocity).	Mean departure from average.	Corresponding mean epoch.	Years before or after sunspot minimum.
	m. p. h.		
1877.3–1879.2.....	+1.11	1878.2	−0.8
1879.2–1880.8.....	+1.24	1880.0	+1.0
1880.8–1883.9.....	+ .25	1882.3	+3.3
1883.9–1885.9.....	− .86	1884.9	+5.9
1885.9–1887.7.....	− .28	1886.8	−2.7
1887.7–1889.5.....	− .62	1888.6	− .9
1889.5–1892.2.....	−1.09	1890.8	+1.3
1892.2–1894.2.....	− .25	1893.2	+3.7
1894.2–1897.4.....	− .03	1895.8	+6.3
1897.4–1899.7.....	+ .22	1898.5	−3.3
1899.7–1901.6.....	−1.06	1900.6	−1.2
1901.6–1904.3.....	− .55	1902.9	+1.1

The figures indicate a general decrease of wind velocity from 1880 to 1890,[a] followed by an increase till 1898, then a decrease till 1901. The first decrease is so marked that the idea of increasing friction in the anemometer suggested itself, but I have ascertained that the instrument has been cleaned and oiled twice a month at least since 1881, when the decrease of wind velocity set in.

Accepting the results as a true record of the variability of wind velocity from year to year, we find a strongly marked eighteen-year periodic effect; two primary maxima occurring in 1880 and 1898, and a primary minimum in 1890. A secondary maximum occurs in 1887, and two secondary minima in 1885 and 1901.

[a] The wind velocity being so much above the average, the negative superposed waves during the negative waves of pressure from April, 1878, to December, 1878, and from February, 1882, to June, 1883, do not appear as actual negative departures from average, as mentioned on page 16.

Smoothing out this effect by hand the figures in the second column of Table XXIX become:

$$+.03+.47+.07-.53+.40+.27-.17+.10-.12+.26-.62+.26.$$

Grouping now according to position in the sunspot cycle, we obtain the following results:

TABLE XXX.—*Grouped values of departure from average of wind velocity, after elimination of two and one-fourth and eighteen years periodic effect (from Table XXIX).*

Separate values.		Mean values.	
Year in cycle.	Departure from average.	Year in cycle.	Departure from average.
	m. p. h.		
-2.7	+0.40	-3.0	+0.33±0.08
3.3	+ .26		
.9	+ .27		
1.2	− .62	- 1.0	- .11± .35
.8	+ .03		
+1.3	− .17		
+1.1	+ .26	+1.1	+ .19± .24
+1.0	+ .47		
+3.3	+ .07	+3.5	+ .08± .02
+3.7	+ .10		
+5.9	.53	+6.1	- .32± .24
+6.3	- .12		

The elimination of the two and one-fourth and eighteen-year periodic effects does not reveal any marked sunspot frequency effect on wind velocity, though the means of the several groups show a slight inequality. Judging by the largeness of their probable errors, however, it would appear that the inequality, as derived from the above figures, is accidental, and that the true solar activity effect, if existent, is marked by other disturbing causes.

The departure from average of rainfall, after eliminating the two and one-fourth year periodic, is given in Table XXXI.

TABLE XXXI.—*Departure from average of rainfall.*

Period (successive maxima of rainfall).	Mean departure from average.	Corresponding mean epoch.	Years before or after sunspot minimum.
	Per cent.		
1877.2-1879.5	+ 3	1878.3	-0.7
1879.5-1881.7	−14	1880.6	+1.6
1881.7-1884.9	+ 2	1883.3	+4.3
1884.9-1886.9	−20	1885.9	3.6
1886.9-1888.0	- 4	1887.4	2.1
1888.0-1889.2	+34	1888.6	.9
1889.2-1891.8	5	1890.5	+1.0
1891.8-1894.4	- 3	1893.1	+3.6
1894.4-1896.4	+21	1895.4	+5.9
1896.4-1899.5	-18	1898.0	3.8
1899.5-1901.9	-12	1900.7	1.1
1901.9-1905.0 (?)	12	1903.4	−1.6

Grouping the values according to their position in the sunspot cycle we have the results given in Table XXXII, which are almost identical with the above, and indicate an increase of rainfall shortly before the

epoch of minimum solar activity and at the epoch of maximum solar activity, with a decrease four years before and two years after the epoch of minimum solar activity.

This double oscillation is not shown in the atmospheric pressure.

TABLE XXXII.—*Grouping values in Table XXXI.*

Separate values.		Mean values.	
Year in cycle.	Departure from average.	Year in cycle.	Departure from average.
	Per cent.		*Per cent.*
−3.6	+20	−3.7	19 ± 1
−3.8	18		
−2.1	−4	−1.6	−8 ± 5
−1.1	−12		
−0.7	+3	−0.8	+18 ± 19
−0.9	+34		
+1.6	−14	+1.4	−10 ± 3
+1.0	−5		
+1.6	−12		
+4.3	+2	+4.6	+7 ± 9
+3.6	−3		
+5.9	+21		

CYCLONES IN THE NEIGHBORHOOD OF MAURITIUS

Mauritius is occasionally visited by cyclones, which do considerable damage when the center passes over or near the island, but are of immense benefit to the colony as one of the principal sources of rainfall. In Table XXXIII is given a list of cyclones which have occurred since 1848 within latitudes 10° to 30° south and longitudes 50° to 70° east of Greenwich, the 20° square of which Mauritius is nearly the center. It will be seen that the cyclone season is at its height toward the end of January, and that no cyclones have occurred within this area in the months from June to September.

Tabulating the yearly totals according to the sun-spot cycle, the figures point to an inequality in the number of cyclones in different parts of the cycle.

TABLE XXXIII.—*Cyclones between the latitudes 10° and 30° south and longitudes 50° and 70° east of Greenwich.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1848	2		1										3
1851			2										2
1852	2												2
1854		1	1								1		3
1855	1				1								2
1856		1	1	1							1		4
1857	1	1	1									1	4
1858	1	1	2										4
1859	2		1	1								1	5
1860	5	2	1		1								9
1861	2	2	1									1	6
1862	2		1								1		4
1863	2	2	2									1	7
1864	2	2		1									5
1865	1	2										1	4
1866	1	1		4									6
1867	1	1		1	1							1	5
1868	2	1	1	1	1						1		7

TABLE XXXIII.—*Cyclones between the latitudes of 10° and 30° south and longitudes 50° and 70° east of Greenwich*—Continued.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1869	1	2	1	.....	1	.....	.....	.....	.....	.....	.....	1	6
1870	1	1	1	1	.....	.....	.....	.....	.....	.....	.....	1	5
1871	1	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	3
1872	1	2	2	1	2	.....	.....	.....	.....	.....	1	.....	9
1873	2	2	1	.....	.....	.....	.....	.....	.....	1	1	.....	7
1874	3	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
1875	3	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	5
1876	2	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	6
1877	2	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	4
1878	2	1	.....	1	.....	.....	.....	.....	.....	.....	.....	1	5
1879	1	1	1	.....	.....	.....	.....	.....	.....	.....	.....	2	5
1880	2	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	4
1881	2	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
1882	.....	2	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
1883	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	3
1884	1	1	1	.....	.....	.....	.....	.....	.....	.....	.....	1	4
1885	2	1	1	.....	1	.....	.....	.....	.....	.....	.....	2	7
1886	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	3
1887	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
1888	1	3	1	.....	.....	.....	.....	.....	.....	.....	.....	1	6
1889	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0
1890	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	3
1891	3	2	1	.....	.....	.....	.....	.....	.....	.....	1	.....	7
1892	1	3	.....	1	1	.....	.....	.....	.....	.....	.....	.....	6
1893	2	1	1	1	.....	.....	.....	.....	.....	.....	1	1	7
1894	1	2	2	1	.....	.....	.....	.....	.....	.....	.....	2	8
1895	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	2
1896	1	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
1897	.....	2	1	.....	.....	.....	.....	.....	.....	.....	.....	2	5
1898	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	3
1899	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	2	4
1900	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
1901	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	4
1902	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	7
1903	3	2	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
Total	72	62	40	19	10	0	0	0	0	2	8	32	244

Information wanting for the years 1849, 1850, and 1853.

TABLE XXXIV.—*Frequency of cyclones during the sun-spot cycle.*

Year of minimum solar activity.	Years before or after the epoch of minimum solar activity.										
	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
1856	2	2	[illegible]	3	2	1	4	4	5	9	6
1867	4	7	5	4	6	5	7	6	5	3	9
1878	7	5	5	6	4	5	5	4	4	4	3
1889	4	7	3	1	6	0	3	7	6	7	8
1901	3	5	3	4	1	4	7	7	.....	.....	.....
Means	4.0	5.2	4.0	3.6	3.8	3.6	5.2	5.6	5.0	5.7	6.5
Inequality	-.7	+.5	.7	1.1	.9	1.1	+.5	+.9	+.3	+1.0	+1.8

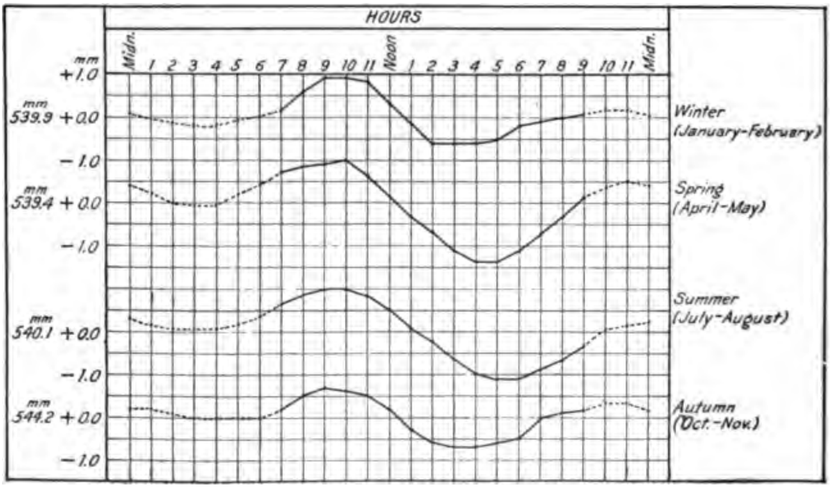
From the experience of five cycles (two of which are incomplete) it would appear that, within the area under consideration, cyclones are most frequent five years after, and least frequent one year before, the epoch of minimum solar activity, though this does not hold good for each individual cycle. At the same time the means give a more regular curve than might be expected, seeing that each is derived from four or five values only, and that the area considered is relatively small. The amplitude of the inequality is from -1.1 to $+1.8$, or, in percentages, from -23 to $+38$ per cent of the mean frequency.

THE CLIMATE OF TS'AIDAM

By A. KAMINSKI

The expedition of the Imperial Russian Geographical Society to Mongolia and Kham (eastern Tibet), which stood under the command of Lieut. (now Capt.) P. Kogloff, besides making regular meteorological observations during the whole voyage, established in Ts'aidam, at Baron Djassak's Khyrma, a complete meteorological station of the second class.

At this station daily observations were made during fifteen months



Diurnal variation of pressure at Ts'aidam.

(from the end of April, 1900, to the end of July, 1901) at 7 a. m., 1 p. m., and 9 p. m. (local time), and during four months—one in the winter, one in the spring, one in the summer, and one in the autumn—hourly observations were made from 7 a. m. to 9 p. m.

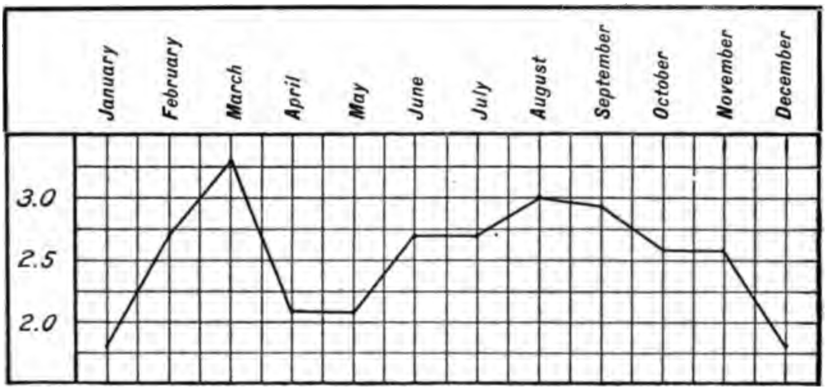
As the whole of the meteorological material of the expedition is not yet worked up, I will communicate only the main results reached by computing the observations of the station in Ts'aidam.

Although hourly observations were made during the daytime only, none being made during the night, yet we can get a representation of diurnal changes of the principal meteorological elements. By comparing the daytime observations at Ts'aidam with those at the nearest stations, we can by interpolation—and with probable accuracy—construct curves representing the full diurnal variation of the meteorological factors at Ts'aidam. The interpolated values are marked by dotted lines on the annexed diagrams.

The curve of the diurnal variation of atmospheric pressure[a] for Ts'aidam[b] differs very little from the same curve for Leh, in Ladak.

The morning minimum is expressed feebly.

The amplitude of the diurnal variation of pressure in the spring, as well as in the summer, amounts to 2–2½ millimeters, but in the autumn and in winter only 1½ millimeters. The study of the general atmospheric currents in a mountainous country is very difficult, on account



Annual variation in wind velocity, in meters per second.

of the existence of local winds, the so-called "mountain breezes," which blow from the mountains in the night and in the inverse direction by day. Such local winds exist also in Ts'aidam, as one can see from the diurnal observations of the meteorological station at Baron Djassak's Khyrma, but from the same observations there can be drawn some conclusions on general atmospheric currents above Ts'aidam.

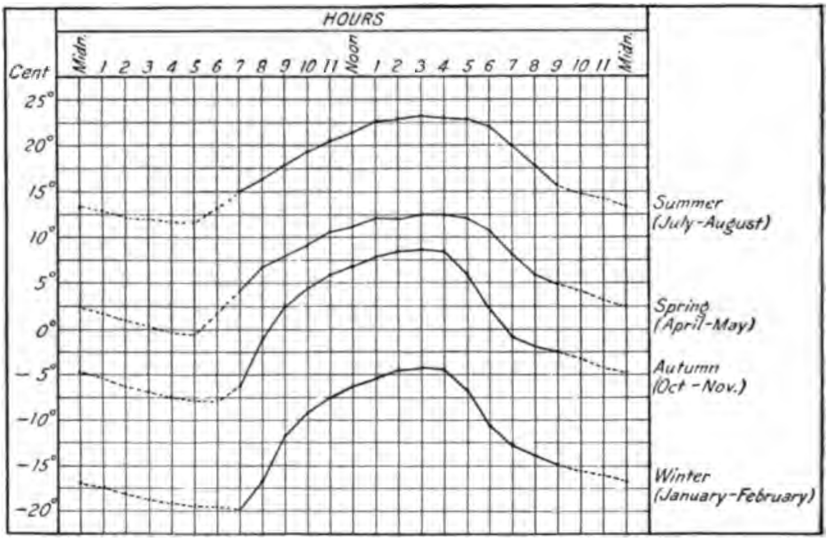
The breeze blows by day from northwest, north, northeast (preeminently from northwest), and in the night from the opposite points of the compass (predominantly from southeast). In winter the general atmospheric currents in Ts'aidam prevail from the southern half of the compass (preeminently from southeast); these winds prevail during the whole winter over winds from other points, by night as well as by day.

[a] The atmospheric pressure was ascertained by an exact mercurial barometer.
[b] By Ts'aidam is always meant Baron Djassak's Khyrma.

In summer north (northwest) winds prevail. The spring in regard to winds forms a transition from winter to summer. As to the autumn, there is no definite indication about a distinct prevalence of some special direction of wind.

The climate of Ts'aidam as to its temperature is somewhat milder than would be expected from its geographical position. The winter at Baron Djassak's Khyrma (latitude 36° 10′ 55″, longitude 97° 21′ 47″ east of Greenwich), at an altitude of 2,860 meters above sea level, has nearly the same temperature (somewhat lower) as in Leh, which lies 2° farther south and 340 meters higher.

The average temperature of the summer at Baron Djassak's Khyrma is about 1° higher than in Leh.



Diurnal variation of temperature.

The average temperature of the coldest month (January) at Baron Djassak's Khyrma proved to be −13° C., and of the warmest (August) 17° C.

From August to December the temperature falls pretty proportionally and moreover more quickly than it rises from February to July.

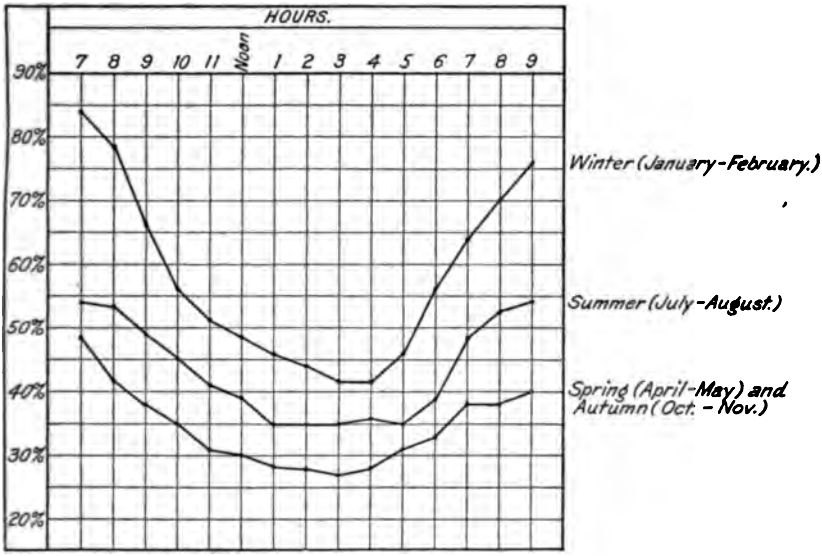
The diurnal variation of temperature of the air in Ts'aidain is generally very large, owing to the great altitude.

The average amplitude of diurnal variation of temperature, based on observations of the maximum and minimum reaches in March and December 20° C., and only during the summer months fluctuates between 14° and 14° C.

The highest temperature, namely 33° C., was observed in June, 1901, and the lowest, −29° C., in February of the same year.

There were during the year two hundred and twenty-six days with frost (ascertained by the minimum thermometer); the last spring frost was noted on the 31st of May and the first autumn frost the 10th of September.

According to the first wholly trustworthy observations on humidity of the air in Ts'aidam, the climate of that country has for its characteristic feature dryness—far less, however, than that of deserts. In January the average relative humidity reaches 64 per cent, but during the other months of the year it is much less. The greatest dryness of the air was observed in March (average relative humidity, 27 per cent); toward the summer the humidity becomes greater (on the average for the months May to August, 47 per cent). Thereupon comes a dry autumn (September–October) with an average relative humidity of about 38 per cent.



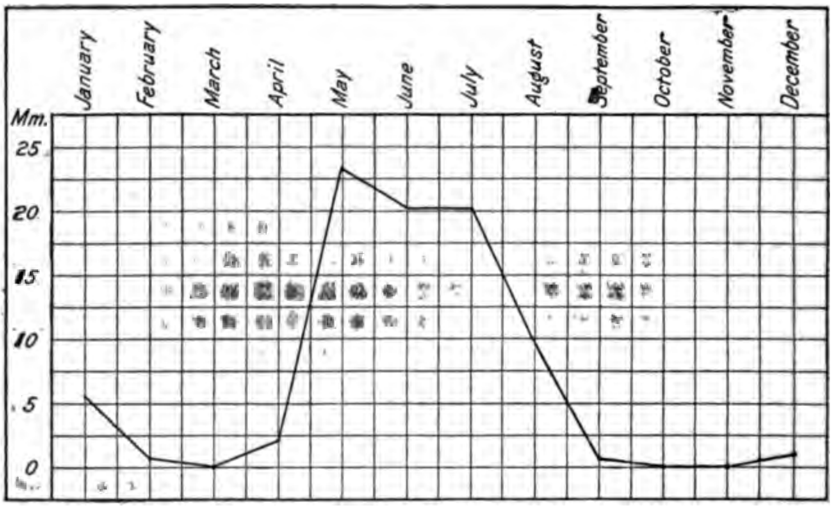
Diurnal variation of humidity.

The observations on the nebulosity seem to be in contradiction with the data for humidity. The driest month -March—has an average nebulosity of 94 per cent, and April and May were about 100 per cent. The autumnal months only, in correlation with the amount of humidity of the air, are relatively clear. In September the nebulosity lessens to nearly 50 per cent.

The great nebulosity in the driest season is explained by the presence at that very time of great quantities of dust in the air, which on one hand favors the condensation of damp and the formation of clouds, and on the other the dust often darkens the sky in such a degree that it may be taken for nebulosity.

There were but very few bright and perfectly clear days.

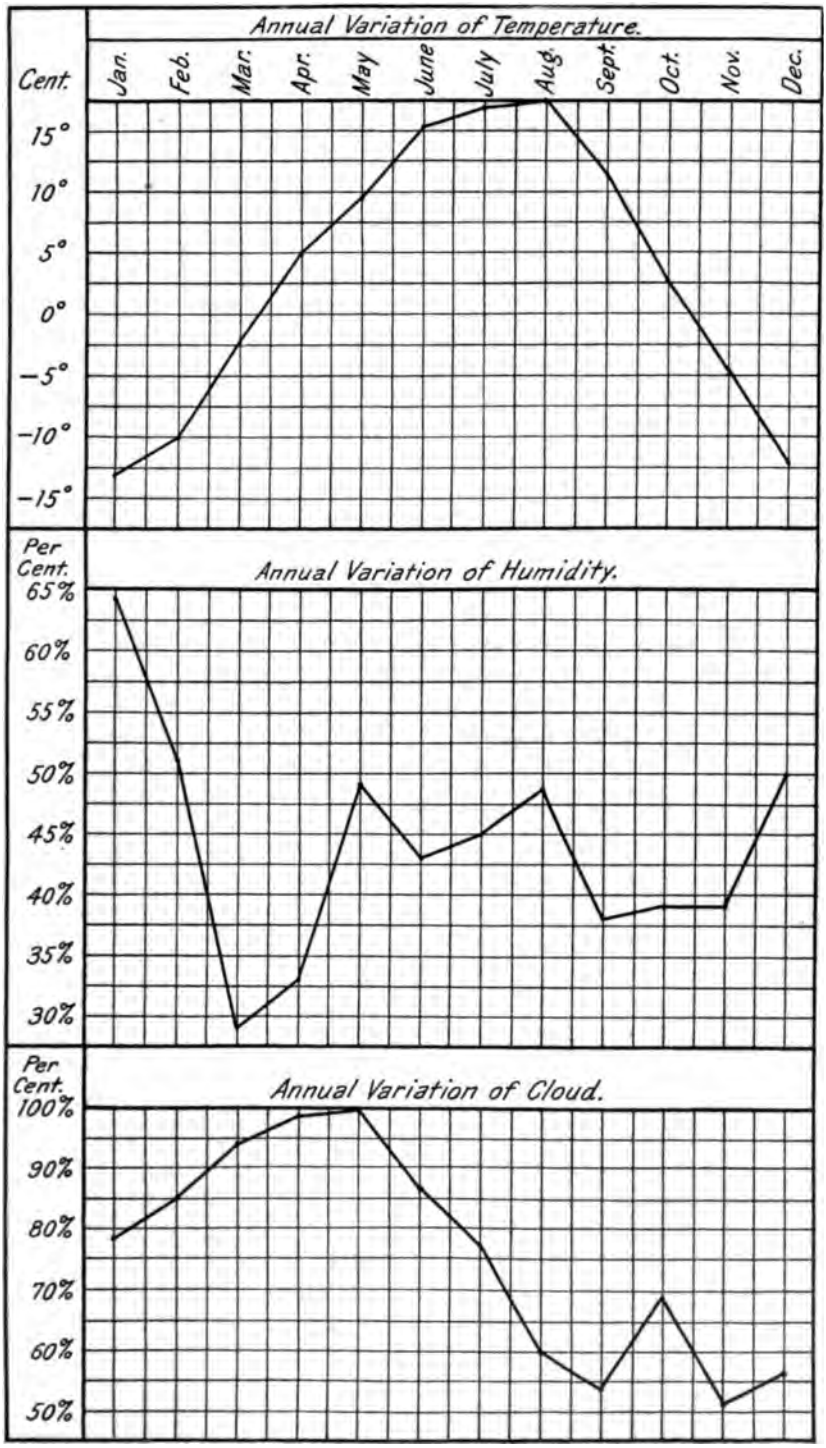
During the whole year there have been measured but 108 millimeters of atmospheric precipitates, i. e., about the quantity which falls in the Trans-Caspian steppes. The most copious precipitation occurs during the months from May to July (over 20 millimeters in a month); the largest diurnal quantity (15.7 millimeters) was registered on the 24th of June, 1900.



Annual variation in rainfall.

Of the forty-four days out of three hundred and sixty-five of the year on which precipitation occurred there were only twelve with snowfall.

Thunderstorms are infrequent. During fifteen months only three have been observed in the near vicinity and two farther off. Heat lightning was registered eleven times.


Annual Variation of Temperature.
Cent.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
15°
10°
5°
0°
−5°
−10°
−15°
Per Cent.
Annual Variation of Humidity.
65%
60%
55%
50%
45%
40%
35%
30%
Per Cent.
Annual Variation of Cloud.
100%
90%
80%
70%
60%
50%

METEOROLOGY OF WESTERN AUSTRALIA

By W. ERNEST COOKE, M. A., F. R. A. S., Government Astronomer of Western Australia

The colonization of Australia practically started from Sydney, on the eastern coast, extending down to Melbourne, then round to Adelaide, and quite recently to Perth, on the west coast.[a]

It was perhaps but natural that people should imagine the weather followed the same law, and it was certainly the prevalent belief in South Australia some thirty years ago that all weather changes were experienced first on the east coast, next at Melbourne, then at Adelaide, and we may suppose that those who troubled any further about the matter would add, finally at Perth, on the west coast. Sir Charles Todd, who has done so much for Australian meteorology, was the first, I believe, to point out that exactly the reverse process was taking place; that in fact weather movements had a general easterly trend throughout the southern portions of Australia. At that time he had no stations to the westward from which daily telegraphic reports could be obtained, but when Western Australia established a meteorological service and shortly afterwards became connected telegraphically with Adelaide (1877) it was a comparatively simple matter to trace the general movement of the "highs" and "lows" from west to east. Old habits of thought are difficult to eradicate and there are still people here who ask whether we are likely to experience a heavy rainfall or severe heat wave just reported from Sydney.

In the study of South Australian meteorology two distinct types of disturbance were found to be the main factors in effecting weather changes, and for convenience let us call these, respectively, summer and winter disturbances.

The winter disturbance is associated with a "low," traveling along the ocean south of Australia and moving in a general east-southeast direction. Before the term "low" was introduced these were generally spoken of as "cyclones," although some doubt existed as to whether they represented a true cyclone. Practically nothing was known of the southern quadrant, but the other three possessed the

[a] This is not intended as a correct historical statement, but to convey a general impression of the manner in which the principal growth evolved.

usual cyclonic circulation, though they were almost always considered to be northern extensions of the normal antarctic low pressure. Heralded from afar by fine weather with light southeast or eastern winds, rising temperature, and falling pressure, the wind veers to the northeast, north, west, and south as the low passes along the ocean, always keeping well south of Adelaide. Light steady rain frequently sets in with the wind at north-northeast or north, and changes to driving squalls as it veers to northwest. This is the time of lowest barometer. It may remain squally with westerly winds for some hours or a few days, according to the shape of the isobars to the west, but by the time the wind reaches south-southwest the storm is practically over.

The summer disturbance seemed to come down from the north of Australia somewhere, but was difficult to trace, owing to the smallness of the barometric gradients and the scarcity of reporting stations. From the information at our disposal it was almost impossible to fix the position of the center, but when the characteristic summer storms occur in South Australia there usually is a "high" near the west and another near the east coast of Australia, with an ill-defined "trough" down the center. As the whole system moves in an easterly direction, heavy rains are frequently reported from the far northern stations, which gradually spread southward and eastward, covering the greater portion of South Australia, New South Wales, and Victoria. These storms are unfortunately of rather infrequent occurrence, and when they fail all except the coastal portions of those three States experience a drought. It is of the utmost importance to the whole of Australia that we should know something more about these storms.

At the time I left South Australia to take charge of the new astronomical and meteorological observatory at Perth, our knowledge of these important summer storms was very limited indeed. It had been noticed that prior to their advent there seemed to be a gradually increasing tendency for the winds between Central Australia and the east coast to set in firmly from the east, and that as the trough sweeping eastward met this region of easterly winds precipitation commenced. There was also the glimmering of an idea that sometimes one of these storms could be roughly traced from the northwest coast of Western Australia across the interior to the Great Australian Bight, and that the effects of this were experienced in South Australia.

When I came to Western Australia in 1896 I personally visited nearly all the existing stations, provided new instruments where necessary, drilled the observers in their duties, established a few new stations, and commenced the daily issue of weather maps, followed before long by forecasts. I have from the first taken special interest in the summer storms which visit our northwest coast, though even now the distances between stations are altogether too great. Still it was not long before it became evident that disturbances which were perceptible

on the northwest coast and traveled overland to the Great Bight, or even into South Australia, were far more common than had been supposed. Some of these disturbances produce hurricanes of tremendous violence with torrential rains on the northwest coast, and, when they can be traced across, the heavy rain frequently follows, proving of great benefit throughout the interior districts. These are, in fact, exactly similar to the summer storms of South Australia, and occur about the same time of the year, viz, between Christmas and Easter. The successive conditions are somewhat as follows:

Heavy rain commences far up the coast, say at Wyndham, or even at Port Darwin, in South Australia; at the same time a "high" becomes established over our southwest corner, and winds generally throughout this State set into the southeast or east. The rain, which is of the steady, heavy kind, as distinguished from the tropical thunderstorms, gradually extends down the coast, while the barometer readings indicate the passage of a "low," keeping well out to sea and moving roughly parallel with the coast line. Meanwhile the "high" over southwestern districts abides and increases, and the winds become more decidedly east throughout, blowing harder and harder. The "low" gradually changes its direction, recurving between latitudes 15° and 20° and striking the coast and wrecking anything near its center, where the barometer sometimes, but not often, falls as low as 27.5. In order that it may travel overland the "high" must now commence to give way, which it frequently does, moving slowly eastward. The further progress of the storm is best seen from a typical example. The following remarks were written for the daily press and will explain themselves. They refer to a storm which occurred in February, 1902:

The weather forecasts for the last week, especially those issued for the gold fields, have been particularly interesting, for they show that a decided forward step has been taken in practical meteorology. For the first time a prognostication of general and heavy rains throughout the interior has been made for several days in advance, and its issue has been attended with complete success.

Special attention is called to this, the first long-period forecast of the kind ever attempted, as it is the result of the study of a series of storms the existence of which was scarcely recognized until the establishment of this observatory. Before that time, and while an officer of the Adelaide government, I had formed a hazy idea that the willy-willies of the northwestern coast occasionally came overland to the Great Bight; but it was not until after my arrival in this State that I realized the frequency of this event and its importance to our gold fields. In order to study more closely this recent addition to Australian meteorology observing stations were established as far inland as settlement and telegraph lines would permit, and our knowledge of the movement of these storms has been steadily increasing. Our observations are even now so few and our stations so scattered that we have as yet only constructed a skeleton frame upon which to build a sounder theory, and there may possibly be several species, but among them are a number of which the recent storm is a splendid type and of which a short description must be of interest to all students of practical meteorology.

These storms sometimes give the first indication of their approach in the extreme

northeastern corner of the State and occasionally, it is believed, at Port Darwin. They travel at first in a southwesterly direction, the center keeping well out to sea, and their presence and movement are shown by an easterly wind, gradually veering north and west, accompanied by heavy rainfall. When they reach latitude 20°, or thereabouts, their course alters, and they recurve and commence to travel in a southerly or southeasterly direction, striking the coast generally between Condon and the Fortescue, and frequently bringing a willy-willy to wreck whatever happens to be in the way. They now travel inland, passing, as a rule, either over or to the east of the gold fields, and bringing more or less rain, according to their intensity. Thence they travel to the Southern Ocean, and across to the eastern States, occasionally bringing general rains, but more frequently, I believe, affecting coastal regions principally.

In the present case a "low" was marked on the weather map of the 4th off the coast somewhere about Derby, and we prognosticated heavy rain extending down the coast. Next morning the presence of a storm somewhere off the coast in the neighborhood of Derby was more pronounced, and accordingly a special storm warning to shipping was sent to all ports north of Hamelin Pool. On the evening of the 5th it was first determined to issue a preliminary warning of coming rain to the gold fields, and the special forecast telegraphed to the daily press at Menzies, Kanowna, Kalgoorlie, Coolgardie, and Southern Cross was as follows: "Fine and warm to hot for the present. There are indications of possibly rainy weather coming down from the Tropics in a few days, but this is at present rather uncertain."

On the evening of the 6th the special gold-fields forecast was: "Fine and warm or hot for the present, but conditions are still favorable for rain within a few days."

At noon on the 7th the following was issued: "Still fine throughout for the present, but the probability of good rains within a few days is now becoming more pronounced."

Some clouds gathered during the 7th at Coolgardie, but on the evening of that day the forecast read: "The gloomy, dull weather now being experienced is not the unsettled weather referred to in recent forecasts. It will probably remain hot or sultry for the present, with perhaps a few scattered thunderstorms here and there. The general rains to which particular attention is directed are connected with a storm center on the northwestern coast, and this is not expected to reach the fields for a few days yet. At present conditions for this development are still favorable."

At noon on the 8th we said: "Fine for the present, but the unsettled weather in the Tropics is making steady progress down the coast and will shortly commence to work inland toward the Murchison."

On the evening of the 9th we wired: "Unfortunately all telegraphic communication north of Perth is interrupted, but from one single report received from Cossack just before the interruption it appears that the storm has just reached that place. During all this time it has been moving in a southwesterly direction, but will probably now recurve and commence to travel inland in a southerly or southeasterly direction, and the probability of heavy rain throughout the interior very soon is now stronger than ever."

At noon of the 10th: "The tropical storm to which special attention has lately been directed has recurved at Cossack, as anticipated, and is now inland. Heavy rain has fallen in the Tropics and as far south as Peak Hill, and light to moderate in places on the fields. It is expected to remain unsettled throughout for the present, with further rains, probably heavy."

By the evening of the 10th the rain had fairly reached the fields, and the forecast stated: "The very interesting storm to which particular attention has lately been directed has now reached the fields, but unfortunately it has sadly interrupted telegraphic communications, and very few reports are to hand. From these, however, it appears that the central track will lie a little to the east of the gold fields, where probably the rainfall will be very heavy. There will also be, as anticipated,

good rains throughout the gold fields. The storm will now gradually work down to the south coast and across to South Australia, and by Wednesday the weather will probably again become fine."

Everybody knows by now, of course, how thoroughly these forecasts were verified, for the rainfall has been general and very abundant. The storm warning to northern ports, issued first on the 5th and repeated more definitely on the 7th, was also fully justified by subsequent events.

Now let us take another look at the winter storms. When studied from South Australia it was generally considered sufficient to note that they first put in an appearance at Cape Leeuwin, the extreme southwestern point of Australia, and thence traveled along the Southern Ocean to Tasmania and eventually to New Zealand; but when my base was shifted to Perth it became necessary to push investigations farther west if possible. With this view the records from the Cape, Natal, and Mauritius were studied in order to see if any of their storms could be traced to Australian waters, but without success. Some of the facts are almost sufficient to justify the assertion that our winter storms certainly do not come from even as far west as the longitude of Mauritius. Two of these may be mentioned:

1. In January, 1901, the Cape experienced a most abnormal season, being visited by a succession of storms of the winter type and the whole month was unusually squally and wintry. From the conservator of forests, Cape Town, I received a communication from which I extract the following:

From the 5th to the 19th of January, and to a less extent for a week or two afterwards, unprecedented summer rain fell in the southwest of Cape Colony. During the sixty years for which we have meteorological records no such rain occurred. * * *

I shall be surprised to hear that the weather in Australia was normal. One would expect that the extraordinary depressions that produced the abnormal weather here in January would pass on to Australia.

As a matter of fact, the weather in Western Australia was fairly normal. The mean pressure was of the ordinary summer type, moderately high to the south, with falling gradients northward, and the weather throughout was that of a very ordinary January.

In South Australia the principal abnormality was the failure of the monsoon rains in the northern territory. Sir Charles Todd reports:

Moderate anticyclones, or high-pressure areas over the southern parts of the continent, are the feature of the weather charts during the month.

It will therefore be seen that a remarkably severe series of the winter type of storm at the Cape failed altogether to make itself felt in Australia and assisted materially to displace from my mind the current opinion that these disturbances travel from South African longitudes.

2. Publication No. 90 of the English meteorological council depicts a number of cyclone tracks in the South Indian Ocean from information collected by Doctor Meldrum, of Mauritius. It is abundantly

evident that during our summer months, December to March, Mauritius lies in the regular path of a series of cyclones which come from the northeast, recurve about latitude 20°, and then travel to the southeast or east-southeast in a direction which would take them well to the south of Australia, in fact south of the high-pressure belt which normally lies along or just south of our south coast line at that time of year. As the winter approaches the number of cyclone tracks shown on these charts diminishes and their location moves eastward, the latitude of recurvature at the same time decreasing. Between May and November every track recorded lies well to the east or northeast of Mauritius.

These two facts, taken in conjunction with the utter failure to trace individual disturbances from either South Africa or Mauritius to Australia, seriously shake, if they do not altogether shatter, the prevalent opinion that the winter "lows" which sweep along the south coast of Australia are northerly extensions of the Antarctic belt of low pressure traveling round a considerable portion of the globe. We are therefore compelled to look elsewhere for their origin, and the present winter season affords a clue.

It has been already stated that the willy-willy (heavy cyclonic storms) season in the northwest lasts from about Christmas to Easter, but a severe storm was experienced in that district on April 17–18 of this year, much later than usual, and occasioned some surprise. Toward the end of June a fair amount of rain fell in tropical portions of the State, a most unusual (though not unique) occurrence for this time of year, and a later study of the reports seems to indicate the passage of a disturbance of the summer type, but keeping well out to sea, working down roughly parallel to the coast and eventually rounding the Leeuwin and progressing as a regular winter "low." The probability of the essentially similar character of winter and summer "lows" was not, however, definitely recognized until the 11th of the present month, when the following paragraph was contributed to the daily press:

The present weather disturbance is of more than usual interest, as it is of the regular summer monsoonal type, though occurring in the midst of winter. As far back as the 4th heavy rain commenced to fall in northwestern districts with a slight indication of a "low" out at sea. The unsettled weather slowly extended inland and southward, but only to meet a well-established "high" with fine cold weather. The "low," still keeping well out to sea, worked steadily down the coast and the weather gradually became overcast throughout the State as the "high" moved eastward. Winds remained easterly and heavy rain continued in the northwest, with lighter showers and atmosphere surcharged with moisture throughout. Progress has continued and very heavy rains fell yesterday between Perth and Geraldton. All this occurred with easterly winds, but the "low," as was anticipated, is now rounding the Leeuwin and will probably progress in future as an ordinary winter storm and travel eastward. In accordance with this, winds are veering westerly and seas are commencing to rise on the southwest coast, while the weather has at last cleared in the northwest.

Next day (July 12) I wrote:

> The recent disturbance is now a quite typical winter storm, passing along the ocean just south of our southeast coast line and giving west and southwest gales and high seas.

The conclusions at which I have arrived are now fairly obvious. It seems—

1. That there is only one type of storm which affects Western Australia and probably most of the continent the whole year round.

2. That there is no such thing as a northward extension of the antarctic low pressure as a practical factor in our meteorology, but that all our disturbances are born somewhere in the tropical regions and follow the usual course, first southwest, then recurving and moving in a southeast and east-southeast direction.

3. That in summer their favorite path lies near our coast line, which they sometimes strike as they recurve, and in this case they pass through the interior of Western and South Australia, giving bountiful rains.

4. That in winter their main path lies some distance to our west, and as a rule their approach is not perceived until nearing the Leeuwin.

As to the character of the seasonal variation of this track in longitude I am not yet prepared to venture an opinion. It may be a gradual movement westward as the winter approaches and a surge back eastward when the sun commences to move south. Or, on the other hand, the easterly movement of the main track of the Mauritius hurricanes, which Doctor Meldrum's observations undoubtedly indicate, may continue, and our winter storms may be but a continuation of the series which passed near Mauritius in the previous summer, and in turn these may progress and become our own next season's summer series.

This raises a very interesting and highly important practical question and gives a glimpse of the possibility of seasonal forecasts, which it shall be my endeavor to further elucidate.

Unfortunately all the official meteorologists in Australia have numerous other duties to perform and can spare but little time for research. This is highly regrettable, because in many ways Australia offers a good field for meteorological investigation. The weather types and sequences appear to possess a more simple character than in some other places, and I believe that a well-conducted department of research would reap a rich harvest of practical discoveries. Let us hope that before long the new federal government will create a central bureau to work harmoniously with existing institutions, utilize their records, and carry out a grand scheme of inquiry into the meteorology of Australia and its neighboring oceans.

ON THE UNSYMMETRICAL DISTRIBUTION OF RAINFALL ABOUT THE PATH OF A BAROMETRIC DEPRESSION CROSSING THE BRITISH ISLES

By HUGH ROBERT MILL, D. Sc., London, England

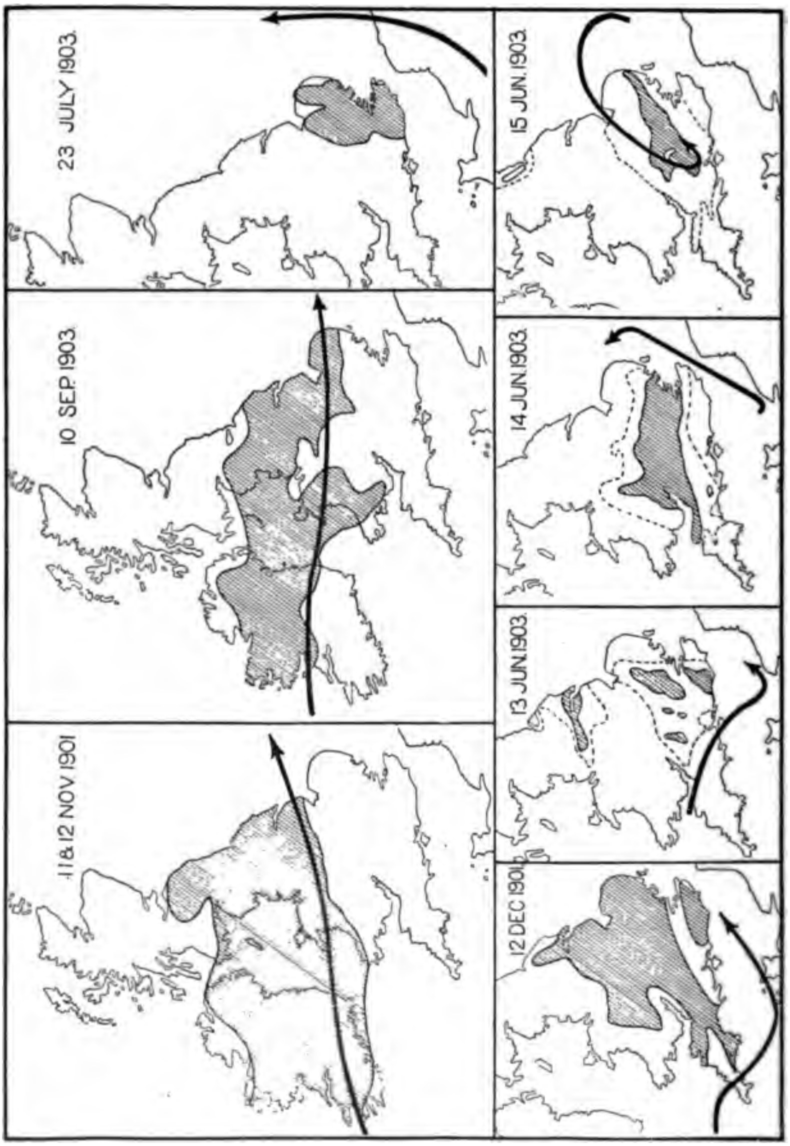
In the course of studying the distribution of rainfall for publication in the annual volumes of British Rainfall much attention has always been paid to individual days on which heavy rain fell. These heavy rains are divisible into two categories, which for convenience may be termed "thunderstorm rains" and "cyclonic rains." The former are typically of irregular distribution and short duration, the rainfall sometimes exceeding 3 inches in a single hour in patches separated by stretches of country where no rain falls. The latter are typically of uniform distribution over wide areas, with falls sometimes exceeding 3 inches in twenty-four hours, but rarely falling at a rate greater than 0.50 inch per hour. Cyclonic rains are characteristic of the winter months, although they may occur at any time of the year.

Ten instances of severe and widespread cyclonic rains have been investigated by the author. The method adopted was to plot upon a map the rainfall for the day considered (9 a. m. to 9 a. m.) at all stations for which the figure was available, and then to draw lines limiting the areas within which the falls exceeded 0.50, 1, 2, 3, and 4 inches, respectively. No cases were investigated in which there was not a considerable area with more than 1 inch of rain. The number of points from which the map was drawn varies from a few hundred to 2,000 or more, according to the extent of surface affected. The maps, reduced to a small scale, have been published in British Rainfall during the last four years. The position of the lines may be relied upon as correct on the scale shown, the probable error lying in most cases within the thickness of the lines as drawn. For the present discussion the path of the barometric depression associated with the rain is added from the monthly summary of the Weekly Weather Report of the meteorological office.

Maps were prepared of 10 cases in which the path of the depression is directed toward different points of the compass. The positions of the center are marked for the hours of observation from 8 a. m. on one day to 8 a. m. on the next, thus corresponding very closely with the rainfall day, 9 a. m. to 9 a. m. Seven of these are reproduced in the accompanying illustration.

The 10 cases include 2 in which the center described a path nearly from south to north:

(1) *October 27, 1903.*—Path from the Lizard along the eastern border of Wales to the Solway. The area with rainfall over 1 inch extended from south to north, reaching considerably beyond the position of the center at 9 a. m., and a larger area, though perhaps not a



Instances of unsymmetrical relation of the area of heavy rainfall about the path of a cyclone. The shaded areas represent rain exceeding 1 inch during the twenty-four hours for which the path of the cyclone is shown.

greater volume of rain, lay to the right of the track than on the left. This is the only instance of the kind in the 10 cases.

(2) *July 23, 1903.*—The center traveled northeastward from near Ushant through France and passed into the North Sea northward through Holland. The area, with more than 1 inch of rain, extended due north from the coast of Sussex and Kent to the Wash, and in the center the falls exceeded 3 and at some points 4 inches. The whole wet area lay well to the left of the path.

Two cases in which the path was first directed toward the southeast and curved round to northeast:

(3) *December 12, 1901.*—At 8 a. m. on the 12th the center was in the Bristol Channel, at 6 p. m. in the English Channel south of the start, and at 8 a. m. on the 13th south of Selsey Bill. The rainfall exceeded an inch from Cornwall to Kent on the southeast and the Tees on the northeast, the whole lying well to the left of the path.

(4) *October 8, 1903.*—The center at 8 a. m. was on the coast of Cardigan, at 6 p. m. near Oxford, and at 8 a. m. on the 9th out in the North Sea in the latitude of Flamborough Head. The rainfall exceeded an inch in the eastern half of Great Britain from the Humber to the Forth, and exceeded 3 inches on the coast of Northumberland. The whole wet area lay to the left of the path.

Two cases in which the path was nearly straight from west to east:

(5) *November 11 and 12, 1901.*—The center was near Valencia on the 11th, about Tipperary at 8 a. m. on the 12th, to the south of Carnarvon at 6 p. m., and in the North Sea off Grimsby at 8 a. m. on the 13th. Falls exceeding an inch prevailed over Ireland, western Wales, and northwestern England on the 11th, and over northeastern Ireland, northern England, and southern Scotland on the 12th, extending on each day from 150 to more than 200 miles to the left of the path, but on neither day more than 50 and rarely more than 25 miles to the right.

(6) *September 10, 1903.*—The path ran from County Clare to Norfolk; the center was off the Arran Islands on the 10th at 2 p. m., south of Carnarvon at 6 p. m., and in the middle of the North Sea at 8 a. m. on the 11th. This center crossed the British Isles in about sixteen hours, while No. 5 required at least thirty hours; but although the center moved more quickly, the area over which an inch or more of rain fell was not much smaller. It extended for about 130 miles to the left of the path and, except for a narrow strip along the coast of Wales, only for from 5 to 30 miles to the right of the path. If the paths of the two depressions Nos. 5 and 6 are superimposed to allow for the slight difference in direction, the similarity of the broad wet strip to the left and the narrow wet strip to the right is most striking.

Three consecutive days in June, 1903, showed remarkable features:

(7) *June 13, 1903.*—The path ran from the Bristol Channel to the

northern coast by Captain McClure.[a] Collinson noted an eastern set in Dease Strait far to the east,[b] and McClure found a large quantity of American pine, almost certainly from the Mackenzie River, drifted into Prince of Wales Strait.[c]

McClure Strait is constantly filled with ice, probably coming in chiefly from the west.

The existence of the current far to the north of Russia is pretty well established by the drifting of the steamship *Jeannette* from Herald Island to a point northeast of New Siberia, where she was crushed in the ice, and by the subsequent drifting of some papers and clothing from the sunken vessel across the polar sea to Julianehaab, near Cape Farewell. The *Jeanntte* was frozen in the ice September 6, 1879, and was crushed June 12, 1881, having made good a distance of 600 miles. During the last five of these twenty-one months much more than half of all the distance made good was covered, and during the last twenty-six days almost one-sixth. The relics were picked up in 1884, or three years after the sinking of the boat, having gone a distance of at least 2,900 miles.

Before undertaking his famous voyage in the *Fram*, Nansen adduced, as further evidence of this current, the finding on the coast of Greenland of an implement which almost certainly came from the Alaskan Eskimos in the vicinity of Bering Strait; also the prevalence of driftwood on the Greenland coasts and the north coast of the Spitzbergen Islands, the species indicating that a large portion of this wood came from northern Siberia.

The voyage of the *Fram* verified his previous calculations in a remarkable manner. That vessel became fast in the ice at a point northwest of New Siberia, September 22, 1893. It thence drifted to a point north of the Spitzbergen Islands, having passed about midway between Franz Josef Land and the North Pole. It was released from the ice June 14, 1896, thus having drifted for thirty-three months, the distance made good being 900 miles. At the beginning of the drifting the rate of the current was a little more than half a mile a day, and increased to 1 mile near the end.

Having established the existence of these two prevailing surface currents, and noting that both eventually flow to southern Greenland, the question arises, Why did not the *Jeannette* drift almost due north instead of bearing off to the west? The *Fram* went almost directly toward the eastern coast of Greenland. It is true, that after the loss of the *Jeannette*, Commander De Long and his party found themselves on ice drifting rapidly northward. As already noted, the last twenty-six days' drifting of the boat covered about one-sixth of the

[a] McClure, The Discovery of the Northwest Passage, edited by Osborn, p. 71.
[b] Collinson, l. c., p. 291.
[c] Richardson, The Polar Regions, p. 232.

EVIDENCES OF LAND NEAR THE NORTH POLE[a]

By R. A. HARRIS, United States Coast and Geodetic Survey

It is a well-established fact that there are two important surface currents (or drifts) in the Arctic Ocean. One of these flows eastward along the northern coast of Alaska, through the Arctic Archipelago, finally reaching the Atlantic Ocean through Davis and Hudson straits. The other starts in the neighborhood of Herald Island, northwest of Bering Strait, and thence flows northwestward, passing north of New Siberia, thence north of Franz Josef Land and the Spitzbergen Islands, and through Denmark Strait to and around Cape Farewell. Therefore these currents are near together when they are north of Bering Strait and again when they are in the vicinity of southern Greenland.

Some evidence of the American current may be cited. The ships *Advance* and *Rescue*, of the first Grinnell expedition, were for a while carried northward in Wellington Channel by the drifting ice; but when near the north end of the channel the current reversed, and thereafter they were carried southward and eastward through Barrow Strait, Lancaster Sound, Baffin Bay, Davis Strait, to latitude 65° 30′ north, where they got themselves free from the ice. The amount of southeasterly drifting measures about 1,000 nautical miles, and required a little more than six months, extending from November, 1850, to June, 1851. This gives an average rate of 5 miles a day.

In May, 1854, the British ships *Intrepid* and *Resolute* were abandoned off the western end of Barrow Strait. The *Resolute* was picked up off Cape Mercy, in the south end of Davis Strait, in September, 1855. During these sixteen months they covered 1,100 miles, making an average rate of 2¼ miles a day.

Strong easterly currents are encountered in Fury and Hecla Strait and in Bellot Strait.

Northeasterly currents off the northwestern coast of Alaska have been noted by Captain Collinson,[b] and easterly currents along the

[a] The greater portion of this paper was published in the National Geographic Magazine for June, 1904.

[b] Collinson, Journal of H. M. S. *Enterprise*, edited by his brother, pp. 137-142.

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[a] McClure, The Discovery of the Northwest Passage, edited by Osborn, p. 71.
[b] Collinson, l. c., p. 291.
[c] Richardson, The Polar Regions, p. 232.

entire distance. These facts suggest a broad strait north of Bennett Island, beyond which is the corner of a large tract of land dividing the deep Arctic channel traversed by the *Fram* from the shallow sea through which the *Jeannette* drifted. The final accelerated rate and northward direction of De Long's drift seem to indicate proximity to this strait.

This sea extends from Bennett Island to Banks Land. It is about 30 or 40 fathoms deep along the track of the *Jeanette*, and perhaps from 100 to 200 fathoms west of Banks Land, where it is known as Beaufort Sea.

That land probably extends to the north of Beaufort Sea can be inferred from the fact that the ice found here is very old, the sea seeming to have no broad outlet through which the ice can escape, as it does north of Siberia. The openings to the east are long and rather narrow channels. This does not argue against a tolerably broad expanse of water extending westward, for the currents setting eastward prevent the ice from escaping to the west. It seems probable that land, continuous or nearly so, must extend far westward from off Banks Land, for this supposed land and the eastward currents might well explain why it is that the ice never recedes far northward from the northern coast of Alaska nor westward from Banks Land.

Osborn thus speaks of the ice encountered by McClure in Beaufort Sea:

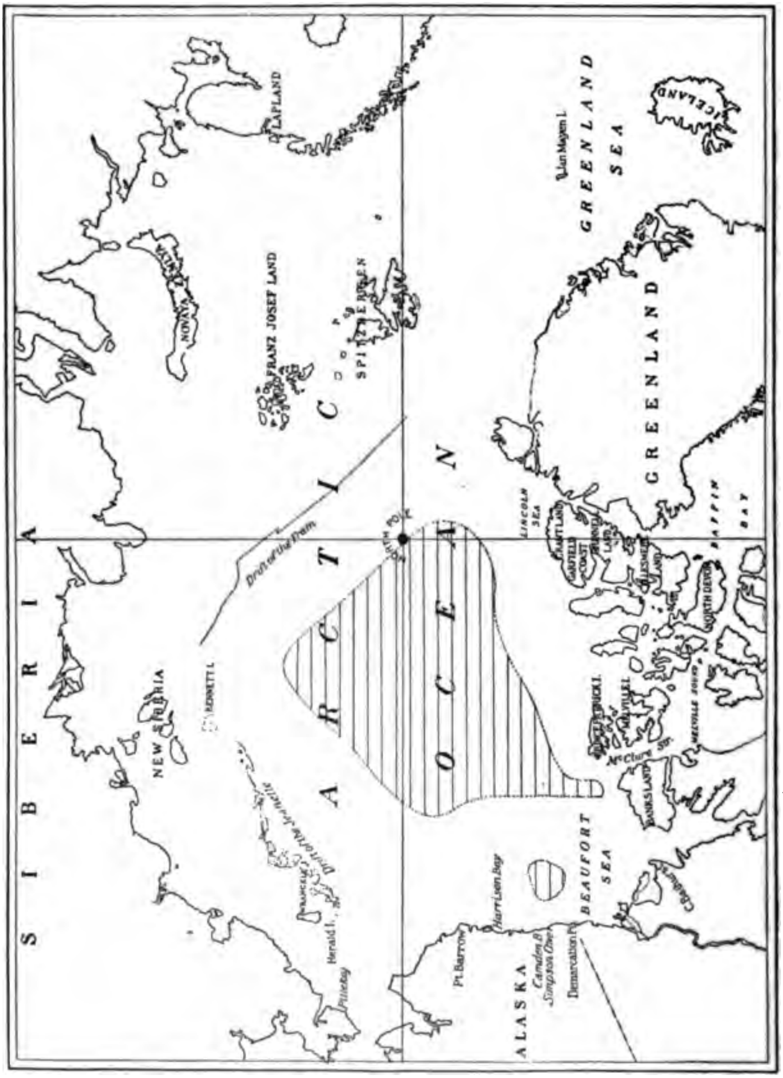
> Ice of stupendous thickness and in extensive floes, some 7 or 8 miles in extent, was seen on either hand; the surface of it not flat, such as we see in Baffins Strait and the adjacent seas, but rugged with the accumulated snow, frost, and thaws of centuries.[a]

Such are the arguments for the existence of a tract of land extending from near the northwest corner of Banks Land, or from Prince Patrick Island, to a point north of New Siberia, based upon the drifting of the ice on the one hand and upon its age and comparatively slight movement on the other hand.

Let us next consider what are the indications from the tides. In the first place, the tide at Point Barrow is semidiurnal in character, with a mean range of 0.4 foot, the flood coming from the west. This can not come through Bering Strait, because the tide immediately south of the strait has scarcely 1-foot range, with a large diurnal inequality, and at a short distance north of the strait, at Pitlekaj, where the *Vega* wintered in 1878–79, the range of the semidiurnal tide was carefully measured and found to be only 0.2 foot. Whence comes the Point Barrow tide? It can not come from the north or east, because all observers agree that the flood comes from the west, and that it is high water on the western side of the point considerably earlier than

[a] McClure, l. c., p. 83.

on the eastern.[a] De Long's party made careful observations upon the tide at Bennett Island, and these show a range of 2 feet. Such a range, diminished by the broadening of the shallow sea to the east of this island, might well be reduced to that found at Point Barrow, provided one considers that the range generally diminishes off headlands



Map of the arctic regions, showing outlines of indicated north polar land.

and capes. On the other hand, if no land exists north of Point Barrow, how can the tide there be much less than that found at Bennett

[a] Simpson, Thomas, Discoveries on the North Coast of America, 1836–1839, pp. 161, 162, 167. Accounts and Papers, Navy, vol. 42 (1854), p. 162. Ray, Lieut. P. H., Report of the International Polar Expedition to Point Barrow, Alaska, p. 678.

Island, and how can the flood come from the west? For practically all of the Arctic Ocean tide is derived from the Atlantic, chiefly through the Greenland Sea, and without land near the pole one of these stations would be reached about as well as the other.

The reasons for not drawing the boundary straight from the Bennett Island corner to the Banks Land corner, but deflecting it to the south, are, first, the apparent necessity for such a bend in order that the direction of the flood may better accord with observation, and that the times of the tides of northern Alaska may be consistent with those at Bennett Island, and, second, the small north-and-south movement of the ice north of Alaska indicating that the sea is here probably narrower than it is farther west, or north of Siberia.

In the extreme north this land can not extend much beyond the pole toward Franz Josef Land, because this would undoubtedly have there caused a bend in the track of the *Fram's* drift. Furthermore, the undiminished range of tide at Bennett Island perhaps indicates that the Nansen channel does not greatly broaden at the pole.

Between this supposed land and the islands recently discovered by Sverdrup may be other islands, forming a continuation of the Arctic Archipelago, and separated from one another by channels of moderate depths, or perhaps this land approaches the Garfield coast and Grant Land. At any rate, the range of tide diminishes from 2 feet at Cape Sheridan to 1½ feet at Northumberland Sound, Penny Strait; and Lockwood and Brainard judged the tide to be small at Greely Fiord. These indicate that the access of the tide from the north is not altogether unrestricted; in fact, part of the tide at Northumberland Sound comes from the east through Belcher Channel.

We come now to another question. A few tides have been observed along the northern coast of Alaska by the explorer, Thomas Simpson.[a] They show that the tide on the outer coast occurs nearly simultaneously from Point Barrow to Camden Bay and Simpson Cove. But as the international boundary line is approached a great change takes place. The tide at Demarcation Point, not 100 miles farther east, is about seven hours later in its time of occurrence. Observations are not sufficient for showing how this change takes place, but it certainly occurs.

A few tides in Mackenzie Bay and farther east have been observed by Captain Richardson[b] and Commander Pullen.[c] The set of the flood along the outer coast is given as eastward for all points where it has been observed from Point Barrow to and beyond Cape Bathurst; but such observations are very meager, probably on account of the small-

[a] Simpson, Discoveries on the North Coast of America, 1836-1839, pp. 115, 117, 121-123, 132, 138, 161-162, 167, 178, 183.

[b] Richardson, Arctic Searching Expedition, pp. 144, 154, 157-160, 169, 175.

[c] Pullen, Reports on Arctic Expeditions, 1882, pp. 35, 38, 40, 51.

ness of the tide. This would seem to preclude the possibility of the principal part of the tide coming from the north or east; hence the probable approach of the polar land to Banks Land, or to Prince Patrick Island, or to Grant Land.

Suppose an island about 100 miles in diameter to be separated from the coast by a shallow strait about 75 miles wide in its narrowest part. By assuming that deeper water exists to the west of the strait and island, and that the tide comes from the west, it seems possible to account for the sudden change in the time of tide, for the main wave going north of the island would control the time of the tide to the northeast of it, and deep water west of the island and shallow strait would cause the tide at Camden Bay and at points farther west to occur remarkably early, just as if this coast were at the head of a deep, suddenly terminated canal extending northwestward.

Immediately east of this supposed strait both Simpson[a] and McClure[b] found that the waves became more like those upon a sea of some magnitude, and the latter, sailing a little north of east, found the depths to rapidly increase from 9 to 32 fathoms, and soon to 195, with no bottom.

Now, the question is, Why this more sea-like appearance unless some huge obstruction lies immediately to the west? It may, of course, be partly due to the open water caused by the influx of the Mackenzie.

It will be of interest to note that several arctic authorities have at various times suspected or inferred the existence of land near the pole. Richardson says:

The Eskimos of Point Barrow have a tradition, reported by Mr. Simpson, surgeon of the *Plover* [in 1832], of some of their tribe having been carried to the north on ice broken up in a southerly gale, and arriving, after many nights, at a hilly country inhabited by people like themselves, speaking the Eskimo language, by whom they were well received. After a long stay, one spring in which the ice remained without movement they returned without mishap to their own country and reported their adventures. Other Eskimos have since then been carried away on the ice, and are supposed to have reached the northern land, from whence they have not as yet returned. An obscure indication of land to the north was actually perceived from the masthead of the *Plover* when off Point Barrow.[c]

On August 15, 1850, Captain McClure, anchored off Yarborough Inlet, about halfway from Point Barrow to Demarcation Point, writes:

The packed ice to-day, as far as the eye can reach, appears solid and heavy, without a drop of water discernible. The refraction has been considerable, giving to the edge of the pack the appearance of a continuous line of chalk cliffs from 40 to 50 feet in height. From the light shady tint, which in different parts of the pack is distinctly visible, I should be inclined to think that there may be many of the same kind of islands as those we have met with, extending to the northward, and impeding the progress of the ice, thereby keeping this sea eternally frozen.[d]

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[a] Simpson, l. c., p. 176.
[b] McClure, l. c., p. 82.
[c] The Polar Regions, p. 240.
[d] McClure, l. c., p. 81.

Captain Collinson, who wintered at Simpson Cove, 1853–54, actually undertook a sledge journey in the spring northward, one object of which was to see if land would not be reached. The roughness of the ice caused him soon to abandon the project. He writes:

I therefore returned, and with sorrow gave up an attempt which * * * I had looked forward to with much interest, thinking that, with anything like a favorable road, I should reach 73° north latitude, and settle the question with regard to the open sea, which certainly does not appear to exist here in the same manner as it does to the north of the Asiatic continent.[a]

In 1873 Admiral Sherard Osborn read a paper before the Royal Geographic Society in which he maintained the existence of an archipelago or land extending from near Prince Patrick Island up very near to the pole and thence to Wrangell Island, thus forming the northern boundary of a nearly inclosed sea.[b]

A probably less happy prediction was made by Petermann, who contemplated land extending northeastward from Greenland, thence across the pole to Wrangell Island.

Sir Clements Markham is quoted as having said in November, 1896:

Personally, as I do not believe in any land near the pole, or on this side of it beyond Franz Josef Land, I trust an attempt will be made to explore another portion of the arctic regions. I believe there is land, probably in the form of large islands, between Prince Patrick Land and the New Siberia Islands.[c]

Prentiss discredits there being much land north of Bering Strait, but his reasons for so doing can hardly be regarded as convincing.

The following quotation is from a paper by Marcus Baker, in volume 5 of the National Geographic Magazine, entitled "An Undiscovered Island off the Northern Coast of Alaska." He suggests that the supposed land be called Keenan Island. The statements cited by Mr. Baker were furnished by Capt. Edward P. Herendeen, who for many years was engaged in whaling.

It is often told that natives wintering between Harrison and Camden bays have seen land to the north in the bright, clear days of spring.

In the winter of 1886–87 Uzharlu, an enterprising Eskimo of Ootkeavie, was very anxious for me to get some captain to take him the following summer, with his family, canoe, and outfit, to the northeast as far as the ship went, and then he would try to find this mysterious land of which he had heard so much; but no one cared to bother with this venturesome Eskimo explorer. So confident was this man of the truth of these reports that he was eager to sail away into the unknown, like another Columbus, in search of an Eskimo paradise.

The only report of land having been seen by civilized man in this vicinity was made by Capt. John Keenan, of Troy, N. Y., in the seventies. He was at that time in command of the whaling bark *Stamboul*, of New Bedford. Captain Keenan said that after taking several whales the weather became thick, and he stood to the north under easy sail, and was busily engaged in trying out and stowing down the oil taken. When the fog cleared off land was distinctly seen to the north by him and all the

[a] Collinson, l. c., p. 312.
[b] Markham, Clements R., The Threshold of the Unknown, pp. 216–224.
[c] Prentiss, The Great Polar Current, p. 105; see also p. 19.

men of his crew, but as he was not on a voyage of discovery and there were no whales in sight he was obliged to give the order to keep away to the south in search of them. The success of his voyage depended on keeping among whales.

The fact was often discussed among the whalemen on the return of the fleet to San Francisco in the fall. The position of Captain Keenan's ship at the time land was seen has passed from my mind, except that it was between Harrison and Camden bays.

It will be noticed that these statements would place the island a little to west of the position shown on the accompanying map.

The hypothesis of a deep polar basin extending from Franz Josef Land and the Spitzbergen Islands to the northern coast of Alaska can be easily disproved by means of the observed diurnal tides; for if this hypothesis be true the Arctic Ocean would constitute an almost ideal body for the production of equilibrium diurnal tides, because its free period of oscillation would then be several times less than twenty-four hours and because the deep basin would be almost entirely surrounded by land or shallow waters. The computed (tropic diurnal) range for this tide would be 0.7 foot at Point Barrow, and at this end of the supposed basin this theory must apply especially well. Observation shows the range there is less than 0.1 foot. This is not due to any local peculiarity, because the range at Pitlekaj is but little greater than at Point Barrow. At Bennett Island and at Teplitz Bay, Franz Josef Land, this diurnal range is 0.3 foot.

The absence of the diurnal wave at Point Barrow can be accounted for in no other way than by assuming that shallow water or land, almost certainly the latter for the most part, extends from a short distance to the north of the Arctic Archipelago nearly to Bennett Island.

The character of the ice around Lands End (or the westernmost point of Grant Land) and along the western coasts of the newly discovered islands, Axel-Heiberg and Isachsen lands, may throw some light upon the approach of polar land to the Arctic Archipelago. Sverdrup describes the ice on the low lands near Lands End as being "sea ice pressed up to quite incredible heights." He says: "North and west of this land, as far as I could make out, was sea, and again sea, with ordinary coarse polar ice."[a]

On the western coast of southern Axel-Heiberg Land he notes pressure ridges of great height. He thus describes the ice found along this coast in latitude 81° north:

About a mile from land a large pressure ridge stretched northward as far as we could see, parallel with the land. The ice inside this ridge seemed to be broken up, and partially to have young flat ice between the fragments, but outside the ridge the ice was apparently oldish coarse ice, with old rounded-off pressure ridges. We received the impression that the whole mass of the ice had receded from land, and that the channel thus made had been frozen over; that later on pressure had taken

[a] New Land, Vol. II, p. 370.

place, and that while this was going on a large ridge had been forced up of young and old ice alternately.

We saw nothing approaching to paleocrystic ice the whole of our journey.[a]

Concerning Isachsen Land he writes:

The most western and northwestern parts of Isachsen Land were also low, a land of sand banks. On its west side the ice was coarse and pressed up in wave-like, more or less parallel, ridges. Violent upheaval must have taken place here, for ridges several yards in height lay pressed right up on land. From Danskesundet up to Cape Isachsen it was evident that there had not been open water for a long time.[b]

Commander Peary thus describes the ice north of Grant Land as observed by him on the 14th and 15th of April, 1902:

Late in the afternoon of the 14th the lead began to close, and hastily packing the sledges we hurried them across over moving fragments of ice. We now found ourselves in a zone of high parallel ridges of rubble ice covered with deep snow. These ridges were caused by successive opening and closing of the lead. When, after some time, we found a practicable pass through this barrier we emerged upon a series of very small but extremely heavy and rugged old floes, the snow on them still deeper and softer than on the southern side of the lead. At the end of a sixteen-hour day I called a halt, though we were only 2 or 3 miles north of the big lead.

During the first portion of the next march we passed over fragments of very heavy old floes slowly moving eastward. Frequently we were obliged to wait for the pieces to crush close enough together to let us pass from one to the other.[c]

In describing his eastward journey along the northern coast of Greenland in 1900, Peary writes:

Up to Cape Stanton we had to hew a continuous road along the foot ice. After this the going was much better to Cape Bryant. Off this section of the coast the pack was in constant motion, and an almost continuous lane of water extended along the ice foot.[d]

* * * * * * *

The two following marches were made in a thick fog, through which we groped our way northward, over broken ice and across gigantic, wavelike drifts of hard snow. One more march in clear weather over frightful going, consisting of fragments of old floes, ridges of heavy ice thrown up to heights of 25 to 50 feet, crevasses and holes masked by snow; the whole intersected by narrow leads of open water, brought us at 5 a. m. on the 16th of May to the northern edge of a fragment of an old floe bounded by water. A reconnoissance from the summit of a pinnacle of the floe, some 50 feet high, showed that we were on the edge of the disintegrated pack, with a dense water sky not far distant.[e]

These quotations seem to show that although the ice along the northern coasts of Greenland and the Arctic Archipelago often becomes pressed up to a great thickness through the action of the winds, it is not of the same character as the old ice found in Beaufort Sea. The eastward drifting observed by Peary shows that the ice gradually

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[a] New Land, Vol. I, p. 405.
[b] Ibid., Vol. II, p. 297.
[c] Bulletin of the American Geographical Society, vol. 35, pp. 529, 530.
[d] Ibid., p. 516.
[e] Ibid., p. 518.

crosses Lincoln Sea and enters the main south-going current east of Greenland. At the same time the northern waterway from Beaufort Sea to Isachsen Land or northern Axel-Heiberg Land must be quite restricted at some point, otherwise the old and extensive floes from Beaufort Sea should be found along the shores to which the quotations relate.

Since the tides clearly prove that there can be no large and deep polar basin extending from Spitzbergen and Franz Josef Land to Alaska, and since the tides and the character of the ice indicate that the land somewhere approaches the Arctic Archipelago or the Arctic Archipelago continued northward, it is difficult to believe that any considerable east-going stream would occur to the north of Grant Land unless land exists still farther to the north and which would form the farther or northern bank. But if land does exist there, as shown in the figure, it is easy to see how a noticeable eastern drift might exist and that Siberian driftwood would be prevented from reaching the northern coast of Greenland, both by the intervention of the land itself and by the east-going drift dependent largely upon it.

The amount of driftwood found along the northern coast of Greenland is small in comparison with that found on the northern coast of Spitzbergen or the eastern coast of Greenland.

DEEP-SEA DEPOSITS

By Sir JOHN MURRAY, Edinburgh, Scotland

[Abstract.]

The difference in elevation between the highest continental peaks and the lowest depths of the ocean is in the neighborhood of 11 miles; between the average continental plain and the average bottom of the ocean, about 3 miles. The depths of the sea are invariable in temperature, free from sunlight, and motionless. The deposition in coastal regions is the source of the stratified rocks. Deep-sea areas are free from such rocks. Here the deposits are largely organic. Toward the poles they are made up of diatoms and siliceous matter. Carbonate of lime deposits are most frequent within the Tropics, the amount of this material present varying with the depth. The summits of the volcanic submarine cones in the South Pacific are composed almost wholly of carbonate of lime, the proportion diminishing with increasing depth until at a point 4 miles below the surface it entirely disappears, probably going into solution. Quartz deposits are found under ice-frequented areas and to the leeward of deserts. In the abysmal regions no quartz sands are at present in course of deposition; here pumice is found and also meteoric particles. All river detritus is deposited in depths of less than 200 fathoms. We are forced to the conclusion that stratified rocks have been built up of this detritus. The abysmal depths of the sea are permanent; the continental areas are changeable.

STRÖMUNGEN DER LUFT UND DES WASSERS

Von EMIL WITTE, Freienwalde, Germany

In den Strömungen der Luft und des Wassers überwiegt die horizontale Componente.

Hinsichtlich ihrer ist für die Luft das Buys-Ballotsche Gesetz massgebend. Dasselbe muss auch für die Bewegung der oceanischen Gewässer gelten. Ist aber seine Bedeutung auch in diesem Falle grundlegend?

1. Die Bewegung der Luft wie des Wassers setzt sich zusammen aus einer horizontalen und einer verticalen Componente, einer Strömung innerhalb einer und derselben Niveaufläche und einem Auf- oder Absteigen von einer Niveaufläche zur andern. In den meisten Fällen, insbesondere an der Grenze der beiden Medien, wo im allgemeinen die Beobachtungen angestellt werden, ist jedoch der Anteil der horizontalen Componente so überwiegend, dass man bei den Strömungen gewöhnlich nur sie ins Auge fasst. Man tut aber gut, sich von vorn herein klar zu machen, dass die horizontale Bewegung nie erfolgt, ohne dass gleichzeitig an irgend welchen Punkten ein Steigen oder Fallen vor sich geht.

Innerhalb jeder Niveaufläche nun, also in horizontaler Richtung, fliesst die Luft von den Punkten höheren Druckes nach denen tieferen Druckes, und zwar in der Richtung der stärksten Druckabnahme, des Gradienten, mit der bekannten Ablenkung durch die Axendrehung der Erde.

Dieser Satz bildet als Buys-Ballotsches Gesetz die Grundlage der Meteorologie. Dass er auch für die oceanischen Gewässer gelte, ist ein Postulat der Physik. Doch wird von einflussreicher Seite behauptet, das Gefälle der Oceane sei zu klein, als dass ihre Strömungen auf diese Ursache zurückgeführt werden könnten. Und sodann kommt bei den Meeresströmen ein Faktor in positiver Weise zur Geltung, der bei den Luftströmungen nur eine negative Rolle spielt, die Reibung. Unterwerfen wir zunächst das Gefälle einer genaueren Untersuchung.

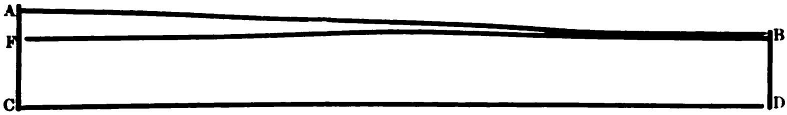
A. DAS GEFÄLLE

Zwei Masse des Gefälles, Bruchform und Gradient.

2. Das Gefälle wird bei der Luft nach einem andern Masse gemessen als beim Wasser.

Das Gefälle eines Flusses ist der Quotient aus der Höhe, um die der Wasserspiegel während des Laufes fällt, und der Länge dieses Laufes. Wenn also das Gefälle 1 : 1000 beträgt, so sinkt der Wasserspiegel um 1 cm während das Wasser von A nach B 1000 cm zurücklegt.

Denkt man sich also durch das Wasser in irgend einer Tiefe die Niveaufläche CD gelegt, so ist die Wassersäule



AC um AF = 1 cm höher als BD. Jedes Teilchen der Wassersäule AC bis zum Boden hinab steht somit unter höherem Drucke als das in demselben Niveau liegende Teilchen von BD.

Dieser Druckunterschied kann gemessen werden durch die Fallhöhe AF, d. h. durch eine Wassersäule von 1 cm Höhe. Zwei in demselben Niveau, etwa bei C und D, angebrachte Barometer müssten den Druckunterschied anzeigen. Und wenn das Quecksilber 13.596 mal so schwer ist als das Wasser, müsste das Barometer bei C um 1 : 13.596 cm = 0.735 mm höher stehen als bei D. Man könnte also auch sagen: Das Gefälle des Wassers beträgt auf 1000 cm Länge 0.735 mm Quecksilberdruck.

Das Gefälle der Luftströmungen wird gemessen durch den Gradienten, d. h. durch die Abnahme des Barometerstandes, während man in einer Niveaufläche senkrecht zu den Isobaren eine gewisse Strecke fortschreitet. Diese Strecke nimmt man gegenwärtig meist zu 1 Meridiangrad oder rund 111 km an, so dass ein Gradient von 1 mm bedeutet eine Druckdifferenz von 1 mm Quecksilber auf 111 km horizontale Entfernung, letztere gemessen senkrecht zu den Isobaren.

Zurückführung des Gradienten auf die Bruchform. Der Gradient 1 mm für Luft ist äquivalent dem Bruch 1 : 10567.

3. Dieses zweite Mass des Gefälles lässt sich auf die reine Bruchform zurückführen durch folgende Betrachtung: Denkt man sich zwischen den Endpunkten des Meridiangrades statt der Luft ein Quecksilbermeer, so ist klar, dass bei einem Gradienten von 1 mm dieses in A um 1 mm höher steht als in B. Daher ist für Quecksilber der Gradient von 1 mm gleichwertig dem Bruch $\frac{1 \text{ mm}}{111 \text{ km}} = 1 : 111.10^6$.

Denken wir uns jetzt statt des Quecksilbers reines Wasser im Zustand der grössten Dichte, so muss, wenn die Druckverhältnisse sich nicht ändern sollen, wenn also die Differenz von 1 mm Quecksilberdruck zwischen den Endpunkten bestehen bleiben soll, das Wasser in A um 13.596 mm höher stehen als in B. Der Gradient 1 mm bedeutet also für Wasser im Zustand der grössten Dichte

$$\frac{13.596}{111.10^6} = \frac{1}{8170000}.$$

Ebenso würde sich für Seewasser von der Dichte 1.027 ergeben

$$\frac{13.596 : 1.027}{111.10^6} = \frac{1}{8390000}.$$

Der Bruch, der sich aus der Reduction des Gradienten ergibt, wird also in demselben Verhältnis grösser, wie die Dichte der Flüssigkeit abnimmt. Da nun normale Luft von 0° C. unter 76 cm Druck 773.4 mal leichter ist als Wasser, so ist der Gradient 1 mm für Luft äquivalent dem Gefälle $\frac{773.4}{8170000} = \frac{1}{10567}$.

Wir haben diesen Schluss hier einstweilen nach Analogie der vorhergehenden Fälle gezogen. Doch wird es immerhin das Verständnis klären, wenn wir uns zwischen A und B ein Meer aus einem gleichmässig dichten, also unelastischen Medium vorstellen, dass genau $13{,}596 \times 773.4 = 10515$ mal leichter ist als Quecksilber. Dann muss es, wenn der Druckunterschied in jeder Niveaufläche 1 mm Quecksilber betragen soll, bei A um 10.515 mm höher stehen als bei B. Das Gefälle ist somit wieder $\frac{10515}{111\ 111\ 111} = 1 : 10567$. Übrigens werden wir dasselbe wichtige Ergebnis auch noch auf anderm Wege erhalten.

Beseitigung eines Bedenkens' Drittes Mass des Gefälles.

4. Gegen die vorstehenden Ausführungen lässt sich der Einwurf erheben, dass die Bruchform des Gefälles sich auf die Länge AB, der Gradient aber auf die Länge CD oder FB bezieht. Allerdings ist der Unterschied offenbar numerisch so gering, dass er auf unsere Zahlenergebnisse keinen Einfluss hat. Doch ist das Bedenken sachlich gerechtfertigt, und seine Erledigung ist für die Folge nicht unerheblich.

Der Unterschied beruht darauf, dass der Gradient Geltung hat für das Gleichgewicht, die Bruchform für die Bewegung, dass also der Gradient ein hydrostatisches Mass ist, während die Bruchform die hydrodynamische Masszahl angiebt. Um beide vergleichen zu können, müssen wir uns vorstellen, dass die Wassersäule CD oder FB in Bewegung gesetzt wird durch den Druck der Säule AF. Dann hat die durch AF dargestellte Kraft, im Beispiel des § 2 bei 1 cm^2 Querschnitt 1 gr^x Kraft, in Bewegung zu setzen die Wassersäule FB und sich selbst, in dem Beispiel 1001 gr Masse, und das Gefälle

ist $\frac{1 \text{ gr}^x \text{ Kraft}}{1001 \text{ gr Masse}}$, wenn man als drittes Mass des Gefälles den Quotienten aus Kraft und Masse annimmt. Seine Dimension ist die des Gravitationspotential-Gefälles.

Ist die Masszahl der Kraft in Gramm gegeben, so stimmt sein Zahlenwert ohne weiteres mit der reinen Bruchform überein. Ist die Flüssigkeit durchweg gleich dicht, so kann man für die Zahlenwerte die Längen einsetzen; dann ist das dynamische Gefälle

für die Wassersäule AB . . . . $\frac{AF}{AB}$

für die Wassersäule AFB . . . . $\frac{AF}{AF + FB}$

Die Änderung ist so gering, dass sie in den Zahlenwerten des vorigen Paragraphen nicht zum Ausdruck kommt.

Zwei Beziehungen zwischen Bruchform und Gradient.

5. Aus den bisherigen Darlegungen ergeben sich zwei einfache Sätze:

(a) Bei gleichem in Bruchform dargestellten Gefälle erfahren alle Flüssigkeiten gleiche Beschleunigung.

Dieser bekannte Satz, denn ich nur der Vollständigkeit wegen anführe, würde sich an der obigen Figur (S. 4) folgendermassen erläutern lassen: Der Druckunterschied zwischen C und D ist bei Quecksilber 13.6 mal so gross als bei Wasser. Ebenso ist aber auch die Masse der zu bewegenden Quecksilbersäule CD 13.6 mal so gross als die entsprechende des Wassers. Mithin ist die Beschleunigung in beiden Fällen dieselbe.

(b) Bei gleichem Gradienten ist die Beschleunigung umgekehrt proportional der Dichte der Flüssigkeiten.

Denn der Druck derselben Quecksilbersäule von beispielsweise 1 mm Höhe hat das eine Mal etwa eine Wassersäule CD zu bewegen, das andere Mal eine Luftsäule von denselben Dimensionen, deren Masse 773.4 mal kleiner ist. Mithin ist die Beschleunigung 773.4 mal grösser.

Diese entspricht aber einem in demselben Verhältnis grösseren Gefälle (in Bruchform); und so führt unser neuer Gesichtspunkt wieder zu dem bereits oben erreichten Ziele, dass das dem Gradienten 1 mm entsprechende Gefälle für die Luft dargestellt wird durch den Bruch 1 : 10567.

Zugleich ergibt sich, dass derselbe Gradient eine um so lebhaftere Luftströmung erzeugt, je niedriger der Luftdruck ist.

Barometerschwankungen veranlassen eine Bewegung des Wassers in jeder Tiefe. Die Bewegung ist am Meeresboden stärker als gewöhnlich angenommen wird.

6. Versuchen wir diese Erkenntnisse anzuwenden auf den Einfluss, den Barometerschwankungen auf das Wasser ausüben können. Ange-

nommen, es habe eine Zeitlang über einem grösseren Meeresgebiete gleichmässiger Barometerstand geherrscht, sodass sich der Stand des Wasserspiegels dem Drucke angepasst hat. Sinkt nun das Barometer über B, so kommt die ganze Wassersäule bis zum Grunde des Meeres unter niedrigeren Druck als das Gebiet A, in dem der Barometerstand sich nicht geändert hat. Es entsteht also im Wasser ein Gefälle in der Richtung AB; und zwar ist für das ganze Wasser bis zum Boden der Gradient derselbe, den die Luft hat. Beträgt er 1 mm, so ist, wie in §3 gefunden wurde, das Gefälle bis zum Meeresgrunde gleichmässig 1 : 8390000, wobei wir die geringe, aus der grösseren Dichte des Tiefenwassers entspringende Abnahme ausser Acht lassen können.

In welcher Weise muss sich nun das Wasser bewegen?

Sehen wir zunächst ab von der Reibung und einer etwaigen Viscosität, so erfolgt die Bewegung nach den Galileischen Gesetzen $v = \gamma t$ und $s = \frac{\gamma}{2} t^2$, in denen v die Geschwindigkeit, γ die Beschleunigung, t die Zeit und s die Länge des Weges bedeutet. Bei dem Gefälle $\frac{1}{l}$ ist die Beschleunigung $\gamma = \frac{g}{l}$, wo g die Intensität der Schwere bedeutet, die wir immer zu 981 cm sec.$^{-2}$ annehmen werden. Dann würde ein Gradient von 1 mm dem Wasser im Verlaufe einer Stunde die Geschwindigkeit $\frac{3600 \times 981}{8390000} = 0.42$ cm verleihen, und das Wasser würde in dieser Zeit 756 cm zurücklegen.

Freilich wird im Verlaufe der Bewegung der Wasserspiegel bei A sinken und bei B steigen, wodurch das Gefälle sich verringert. Es lässt sich aber sehr wohl annehmen, dass gleichzeitig das Barometer bei B weiter sinkt in dem Masse, dass das Gefälle des Wassers eine Stunde lang unverändert bleibt. Ja, diese Annahme dürfte bei heftigen Barometerschwankungen nicht selten hinter der Wirklichkeit zurückbleiben. Wie man aber auch hierüber denken mag, jedenfalls zeigt sich, dass das Wasser, und zwar alles Wasser bis zum Grunde des Oceans, unter dem Einfluss von Barometerschwankungen nicht unerhebliche Bewegungen ausführt.

Sofortige und säculare Wirkung von Verdunstung und Niederschlägen.

7 Ähnlich steht es mit Verdunstung und Niederschlägen. Wenn bei B Wasser verdampft, so kommt dadurch zunächst alles Wasser bis zum Meeresgrunde unter niedrigeren Druck als die entsprechende Niveaufläche bei A, wo keine Verdampfung stattgefunden hat. Es entsteht also für alle Niveauflächen ein Gefälle von A nach B. Ebenso, wenn in A ein Niederschlag erfolgt.

Wenn aber in B dauernd die Verdunstung überwiegt und das Salz-

wasser daselbst concentriert, oder wenn in A Niederschläge und Süsswasserzuflüsse das Wasser immer von neuem verdünnen, muss mit der Zeit eine andern Folge eintreten. Mit dieser säcularen Wirkung der Verdunstung werden wir uns am besten bekannt machen, wenn wir ausgehen von einem einfachen und bekannten Beispiel, den doppelten Strömungen in engen Meeresstrassen, insbesondere in der Strasse von Gibraltar.

Doppelte Strömung in der Strasse von Gibraltar. Abnahme des Gefälles bis zu einer im Gleichgewicht befindlichen Niveaufläche, Umkehrung seiner Richtung und Zunahme bis zum Boden. Säculare Wirkung überwiegender Verdunstung.

8. Nehmen wir der Einfachheit wegen die Zahlen, die ich vor Jahren der Rechnung zugrunde gelegt habe,[a] nämlich die Dichte des atlantischen Wassers 1.027, die des Mittelmeerwassers 1.029, so kann in der Strasse von Gibraltar irgend eine Niveaufläche nur dann in Ruhe sein, wenn das Wasser auf der atlantischen Seite höher steht als auf der andern. Der Unterschied betrage x Meter, und die ruhende Schicht liege 183 m unter dem Spiegel des Mittelmeeres, dann ist $(183 + x).\ 1.027 = 183.\ 1.029$ woraus folgt $x = 0.36$, ein Ergebnis, das mit den inzwischen vorgenommenen Nivellements befriedigende Übereinstimmung zeigt.

Die Niveaufläche in 183 m Tiefe bildet nun die Grenze zwischen zwei Strömen, einem oberen, der atlantisches Wasser in das Mittelmeer bringt, und einem unteren, der in entgegengesetzter Richtung Mittelmeerwasser führt. Nehmen wir, allerdings ziemlich willkürlich, die Strecke, auf die sich die gefundene Fallhöhe von 0.36 m verteilt, zu 100 km an, dann hat die obere Wasserschicht ein Gefälle von $\frac{0.36}{100,000} = \frac{1}{278,000}$ etwa.

In 183 m Tiefe besteht kein Gefälle, und für die dazwischen liegenden Niveauflächen nimmt dasselbe, wie leicht einzusehen ist, gleichmässig ab, so dass es 18.3 m über der ruhenden Schicht, d. h., in 164.7 m Tiefe, $1 : 278.10^4$ beträgt. Es muss daher im Gegensatz zu den Fällen der vorhergehenden Abschnitte (§ 6 und 7), auch abgesehen von der Reibung, die obere Schicht am schnellsten fliessen, und die Geschwindigkeit muss bis zur Tiefe von 183 m gleichmässig abnehmen. Von da an wird der Druck auf der Mittelmeerseite grösser als auf der atlantischen, und das Gefälle der aufeinanderfolgenden Niveauflächen wächst in derselben Weise, wie es vorher abgenommen hat. Es erreicht also bei 201.3 m wieder den Betrag den es in 164.7 m Tiefe hatte, u. s. w. In dieser Zahl ist allerdings die bei 183 m erfolgende Zunahme der Wasserdichte als unerheblich vernachlässigt, die im Nenner des Bruches (§ 4) zum Ausdruck kommen müsste.

Geben die verschiedenen Wasserdichten allmählig in einander über,

[a] E. Witte, Über Meeresströmungen, Pless, 1878, S. 3.

wie das in der Natur der Fall ist, so ändern sich die Zahlenwerte. Immer aber, und das ist das Wesentliche dieser Strömungen, nimmt das Gefälle von der Oberfläche bis zu einer gewissen Tiefe ab, geht dann in das entgegengesetzte über und wächst wieder bis zum Boden, wo es abermals einen Maxinalwert erreicht.

Genau dieselbe Circulation müsste zwischen den äquatorialen und den polaren Gewässern bestehen: die Verdunstung in den Tropen und der Überschuss von Niederschlägen in höheren Breiten müssten im Laufe der Jahrhunderte Strömungen erzeugen—die oberflächlich salzärmeres Wasser zum Äquator, unterseeisch salzreicheres zu den Polen führen—wenn nicht stärkere Motive einer solchen säcularen Wirkung zuvorkämen. Dahin gehört vor allem die Wärme.

Die thermische Verticalcirculation entspringt aus dem Zusammenwirken von Verdunstung und Erwärmung. Ermittelung ihres Gefälles und ihrer Geschwindigkeit.

9. Die unmittelbare Einwirkung der Sonnenstrahlung auf die Temperatur der äquatorialen Gewässer reicht nur bis zu geringen Tiefen. Aber die gleichzeitige Verdunstung lässt dicht an der Oberfläche ein so salzreiches Wasser zurück, dass es bis zu einer gewissen Tiefe sinkt und dem darunter liegenden seinen Überschuss an Wärme und Salzgehalt mitteilt. Auf diesem Wege, durch Convection, sowie durch Wellenbewegung bildet sich eine ziemlich gleichmässig durchwärmte Schicht äquatorialen Wassers, die stellenweise mehrere hundert Meter hinabreicht. Sie hat allerdings übernormalen Salzgehalt, ist aber trotzdem weniger dicht als die tieferen Schichten infolge ihrer hohen Erwärmung. Da also alles in allem die äquatorialen Gewässer bis zu einer gewissen Tiefe eine Ausdehnung erfahren, entsteht durch das Zusammenwirken von Wärme und Verdunstung die Tendenz zu einer Circulation in entgegengesetztem Sinne, als die Verdunstung allein bewirken würde. (Vgl. den Schluss des vorigen Paragraphen).

Indem man nun die Dichteabnahme dieser äquatorialen Wasserschicht in Rechnung zieht, kann man schätzungsweise finden, um wie viel sich der Wasserspiegel in den Tropen über den der polaren Gewässer erhebt. Wenn sich auf diese Weise nach der neuesten von einer anerkannten Autorität[a] ausgeführten Schätzung die Erhebung der äquatorialen Gewässer zu höchstens 2.25 m ergibt, und wenn hieraus ein Gefälle von 1 : 3300000 gefolgert wird, so schliesse ich mich dem einstweilen an. Allerdings ist diesem Gefälle die Entfernung zwischen Äquator und Polarkreis zugrunde gelegt, die 7400000 m beträgt, während es sich im ganzen und grossen nur um die Entfernung zwischen den Tropen und den kalten Zonen handelt, woraus ein etwas stärkeres Gefälle folgen würde, doch lege ich auf diesen Unterschied hier kein Gewicht.

[a] Schott: Physische Meereskunde, Leipzig, 1903, S. 59.

Setzt man die angenommenen Werte in die Formeln des § 6 ein, so ist, in Centimetern ausgedrückt,

$$v = \frac{981}{3300000}\, t, \text{ und } 74.10^7 = \frac{981}{2.3300000}\, t^2.$$

Hieraus folgt $t = 223.10^4$ sec. oder nahezu sechsundzwanzig Tage und $v = 664.4$ cm. Das heisst, das Wasser würde in etwa sechsundzwanzig Tagen mit einer schliesslichen Geschwindigkeit von über 6 m in der Secunde aus den Tropen zum Polarkreis gelangen.

Nun gilt allerdings das angenommene Gefälle nur für die Oberfläche, und es nimmt, wie wir gesehen haben, schon innerhalb der hoch erwärmten Schichten mit der Tiefe ab. Aber trotzdem kann man auf die etwaigen Bewegungshindernisse einen erheblichen Abzug machen, wenn man zu Zahlen gelangen will, die der Wirklichkeit entsprechen.

Bedenken wegen der Kleinheit des Gefälles. Scandinavische Forscher rechnen mit wesentlich kleineren Gefällen.

10. Obgleich also Gefälle von der angegebenen Stärke im Stande sind, im Laufe einiger Tage deutlich wahrnehmbare Strömungen zu erzeugen, fährt Schott an der angeführten Stelle fort: "Dass hierdurch nennenswerte Strömungen nicht ausgelöst werden können, liegt auf der Hand." Und Krümmel[a] behauptet noch von dem Gefälle 1:1200000, es sei "viel zu klein, um eine nachweisbare Stromgeschwindigkeit zu erzeugen."

Diese in Deutschland noch heute vorherrschende Ansicht, der auch ich früher beigepflichtet habe,[b] wird im Anhange des vorliegenden Aufsatzes eingehend erörtert. Es wird daselbst ihre auf Missverständniss beruhende Entstehung und ihre Grundlosigkeit nachgewiesen.

In Übereinstimmung mit der Auffassung, dass die in den Oceanen vorhandenen Gefälle allerdings zur Erzeugung von Strömungen ausreichen, hat in neuerer Zeil eine Anzahl scandinavischer Forscher die Meeresströme behandelt. Der Fortschritt, der in ihren Arbeiten hervortritt, beruht auf einer eigentümlichen Methode zur Ermittelung der Druckverhältnisse und des Gefälles der verschiedenen Wasserschichten. Die Division der Bjerknesschen Solenoide durch den Umfang der Wasservierecke entspricht dem in § 4 angegebenen Verfahren. Der Quotient hat wieder die Dimension des Potentialgefälles. Hierbei wird unbedenklich mit Gefällen gerechnet, die wohl durchweg wesentlich kleiner sind als $1 : 10^6$.

Auch die aus der Erddrehung hervorgehende Ablenkung wird von Sandström und Hansen[c] auf dasselbe Mass zurückgeführt. Auf die Einzelnheiten der Methode einzugehen ist hier nicht der Ort.

[a] Krümmel: Handbuch d. Oceanographie, Stuttgart, 1887, Bd. II, S. 286.
[b] Pogg. Annalen, 1871, Bd. 142, S. 281. Witte Zur Theorie der Meereströmungen.
[c] Sandström und Helland-Hansen: Berechnung von Meeresström., Bergen, 1903.

B. DER WIND

Der Wind beeinflusst die Strömung der oberen Wasserschichten, ist aber seinerseits oft auf die tiefer greifenden Meeresströme zurückzuführen.

11. Die Bewegung der Meeres-Oberfläche erfolgt im allgemeinen in der Richtung des Windes. Wäre dies durchweg der Fall, so hätte die Frage nach der Ursache der Meeresströmungen keine Bedeutung erlangen können. Denn dass der Strom dem Winde folgt, weiss jeder Seemann, und der Grund ist ohne weiteres verständlich. Ebenso wenig Schwierigkeiten bereitet es, wenn bei wechselndem Winde die überwiegende Windrichtung in überwiegendem Grade für die Stromrichtung massgebend ist. Und gerade hierbei zeigt sich die Ablenkung der Strömung durch die Axendrehung der Erde aufs klarste.

Nach diesen Grundsätzen hat Mohn in einer ausgezeichneten Arbeit[a] die Strömungen des europäischen Nordmeeres behandelt. Freilich hat er dabei die Frage nach dem Grunde des über diesem Meere herrschenden barometrischen Minimums unerörtert gelassen und letzteres als gegeben angenommen. Die Auflockerung der Atmosphäre ist aber, darüber kann doch wohl kein Zweifel bestehen, die Folge der warmen in das Meer eintretenden Strömung. So ist also die Windrichtung bedingt durch den Eintritt des Warmwasserstromes; und sie ihrerseits regelt nun allerdings in gewisser Weise, aber, wie sich zeigen wird, nur bis zu geringer Tiefe, die Oberflächenströmung des Wassers.

Das Beispiel zeigt, wie der Einfluss des Windes auf die Wasserbewegung [illegible], während der umgekehrte Einfluss tiefer [illegible] erst auf dem Umwege durch die Erniedrigung des Luftdruckes [illegible].

[illegible] durch ihr Gefälle. [illegible] in physikalischem [illegible]

[illegible] System der Oberflächenströmungen [illegible] Strom nicht oder wenigstens [illegible] W[illegible] [illegible]hrt werden kann, ja, zuweilen [illegible] W[illegible] [illegible]nd das gerade die auffallendsten [illegible] M[illegible] [illegible] diese hat sich bei den Anhängern [illegible] W[illegible] [illegible] das Wort "Compensations-[illegible] [illegible]ch wohl zur Abwechselung [illegible]

[illegible] [illegible]nzuwenden, wenn [illegible] [illegible] Strömung d[illegible] [illegible] nach A[illegible] [illegible] [illegible]hene [illegible] [illegible] Was[illegible]

[a] Mohn, in Peter[illegible]

die Erddrehung von B, etwa in der Breite von Philadelphia, nach Osten getrieben sind Unvermerkt aber hat sich in den Ausdruck ein anderer Sinn eingeschlichen. Es wird nämlich den Worten die Bedeutung einer physikalischen Erklärung der Strömung untergeschoben, die dann bildlich noch unzweideutiger in dem häufig angewandten Ausdruck "Compensationsbedürfnis" hervortritt. Es ist, als ob die Compensation eine neue, von der Gravitation unabhängige Kraft wäre. Das Wasser soll von A nach B ausdrücklich nicht fliessen infolge seines "viel zu kleinen" Gefälles, sondern statt dessen sollen Compensation und Aspiration eintreten. Gegen diese Auffassung, die sich in fast allen deutschen Veröffentlichungen der neuesten Zeit findet, erhebe ich Einspruch und weise nachdrücklich darauf hin, dass das Wasser von A nach B gelangt ausschliesslich vermöge seines Gefälles. Ist dieses klein, nun dann ist eben damit der Beweis erbracht, dass ein kleines Gefälle zur Erzeugung von Strömungen ausreicht.

Gerade bei der Motivierung der wichtigsten und bedeutendsten Ströme kommt also die Windtheorie nicht aus ohne das in ihrer Darstellung durchaus unzureichende Gefälle.

Die Kräfte, mit denen die ausschliessliche Windtheorie rechnet, sind viele tausendmal schwächer als das Gefälle. Der Einfluss des Windes reicht nur bis in geringe Tiefen.

13. Der innere Widerspruch dieser Theorie tritt noch schärfer hervor, wenn man auf ihre Rechnungen näher eingeht. Einundvierzig Jahre muss nach ihr der Windantrieb dauern, wenn man in der Tiefe von 100 m $\frac{1}{10}$ der Oberflächengeschwindigkeit antreffen soll.[a] Nehmen wir letztere zu 1 m, so würde die fragliche Schicht in einundvierzig Jahren eine Geschwindigkeit von 10 cm in der Secunde erreichen. Dieselbe Geschwindigkeit würde sich im Laufe von einunvierzig Jahren ergeben durch das Gefälle $1 : 129.10^9$. Während also das Gefälle $1 : 3.10^6$ keine nennenswerte Strömung erzeugen soll, rechnet man ernsthaft mit Kräften, die 40000 mal kleiner sind.

Nun heisst es freilich: Die tiefgreifende Bedeutung der Windtrift beruht darauf, dass sie die Jahrtausende hindurch unablässig in demselben Sinne wirkt. Aber wirkt die Schwere etwa nicht unablässig? Soll die Bedeutung des Gefälles darum geringer sein, weil es in wenigen Tagen das erreicht, wozu die Windtrift Jahrhunderte braucht? Bevor der Einfluss des Windes sich in grösserer Tiefe geltend machen kann, haben längst andere Ursachen, insbesondere die Verschiedenheit der Dichte ihre Wirkung ausgeübt. Anstelle der Wasserteilchen, die vor einundvierzig Jahren einen Impuls vom Passat erhielten, sind inzwischen wiederholentlich andere Teilchen getreten, die damals andern Stromgebieten angehörten. Der Einfluss der Windtrift kann

[a] Schott: Physische Meereskunde, Leipzig, 1903, S. 146. Ich citiere absichtlich nicht den Urheber der Theorie, sondern eine neue Publication eines angesehenen Hydrographen.

sich also nicht Jahre lang summieren. Sie reicht nur bis in geringe Tiefen.

Der Versuch am Modell beweist nichts für die wirklichen Verhältnisse. Energie der Lage und Energie der Bewegung.

14. "Aber die bekannten Versuche an Modellen zeigen doch, dass der Wind allein genau die Strömungen hervorruft, die in Wirklichkeit bestehen."

Ich könnte hierauf entgegnen, dass der Versuch teilweise das vorweg nimmt, was er zeigen soll. Bewiesen soll werden, dass die vorherrschende Windrichtung für die Strömungen massgebend ist, und das Modell verwendet ausschliesslich diese Windrichtung. Würden an ihm auch nur einige Minuten lang die in der Natur wirklich vorkommenden Luftströmungen angebracht, die Wasserströme würden in völlige Unordnung geraten. Aber ich möchte bei der Gelegenheit doch zahlenmässig nachweisen, warum so ein Versuch im kleinen nicht ohne weiteres auf die natürlichen Verhältnisse übertragen werden darf.

Die Fallhöhe stellt dar eine Form der Energie der Lage. Kommt infolge des Gefälles ein Körper in Bewegung, rollt z. B. eine Kugel eine schiefe Ebene hinab, so verwandelt sich die Energie der Lage in Energie der Bewegung; und am Ende der schiefen Ebene ist, abgesehen von dem Verlust durch Reibung, die ganze Energie der ersten Form übergegangen in die zweite Form. Beide sind gleichwertig und hängen zusammen durch die Formel $v^2 = 2gh$, in der v die Geschwindigkeit, g die Beschleunigung durch die Schwere, und h die Fallhöhe bedeutet.

Und umgekehrt kann ein Körper, der die Geschwindigkeit v hat, vermöge derselben bis zur Höhe h steigen. Hierbei verwandelt sich seine Energie der Bewegung in Energie der Lage.

Kommt also in dem erwähnten Modell die Äquatorialströmung auch nur mit 1 cm Geschwindigkeit in das "amerikanische Mittelmeer," so besitzt sie eine Energie, die der Fallhöhe $h = \frac{v^2}{2g} = \frac{1}{1962}$ entspricht. Vermöge dieser Höhe ist sie sehr wohl im Stande auf dem Modell beispielsweise 1 m zu durchlaufen. Das Gefälle 1 : 196200 ist um so mehr ausreichend, als die Strömung im "Busen von Mexiko" nicht zur Ruhe kommt, sondern ihre Geschwindigkeit beibehält.

Kommt aber der wirkliche Äquatorialstrom selbst mit 100 cm Geschwindigkeit in den Golf von Mexiko, so ist die entsprechende Fallhöhe immer erst $\frac{10000}{1962}$ oder etwa 5 cm. Nehmen wir für die weiter zu durchlaufende Strecke wieder 7400 km an, so würde sich hieraus ein Gefälle von $1 : 148.10^6$ ergeben, das für die Entstehung des Golfstromes gerade für die Anhänger der Windtheorie durchaus unzureichend ist.

Hierbei ist, abgesehen von andern, nahe liegenden Einwürfen noch

nicht berücksichtigt, dass der Windstau an der flachen Küste des Modells nicht etwa einen kleineren, sondern im Gegenteil einen grössern Wert ergibt als an der wirklichen Küste des Oceans. Kurz, der Versuch hat für die wirklichen Verhältnisse keinerlei Beweiskraft.

Den Äquatorial-Gegenströmen liegt nur ein kleines Gefälle zugrunde. Der Golfstrom wird durch kleine Änderungen des Gefälles erheblich beeinflusst.

15. Der Wind vermag allerdings, indem er das Wasser von einem Punkte der Oberfläche fortführt und an einem andern anhäuft, Gefälle zu erzeugen. Dass diese, auch wenn sie sehr klein sind, für die oceanischen Strömungen eine erhebliche Rolle spielen, dafür möchte ich noch zwei Tatsachen anführen:

(*a*) Die Äquatorial-Gegenströme. Für sie besteht kein anderes Motiv als das rückwärtige Gefälle der vom Passat aus den östlichen Teilen der Oceane weggetriebenen und im Westen aufgestauten Wassermassen. Messungen über die Stärke dieses Gefälles gibt es kaum. Colding veranschlagt die Höhe des Windstaues auf der amerikanischen Seite des Atlantic zu etwa 1 m, und meines Wissens ist dem nirgends widersprochen. Schliessen wir uns ihm an, so ergibt sich für den Gegenstrom, der doch frühstens bei 45° west. Länge beginnt, jedenfalls ein sehr geringes Gefälle. Aber wie klein es auch erscheinen mag, zur Erzeugung des Gegenstromes muss es doch wohl gerade ausreichen. Mit dem Worte Compensation[a] kommt man über die Schwierigkeit nicht hinweg.

(*b*) Die Mächtigkeit des Golfstromes ist in hohem Grade abhängig von den Jahreszeiten. Er hat[b] seine grösste Geschwindigkeit Ende August, wo der Golf von Mexiko um 20 cm. höher steht als im Januar und Februar. "Die Geschwindigkeit des Golfstroms scheint also dem Wasserstande im Golf von Mexiko zu folgen." Wenn nun schon eine so unbedeutende Erhöhung des Wasserspiegels im Stande ist, die Strömung in auffallendem Grade zu verstärken, so scheint der Schluss berechtigt, dass tatsächlich, in Übereinstimmung mit der in diesen Blättern vorgetragenen Theorie, schon ein schwach erscheinendes Gefälle im Verlaufe von Tagen eine wahrnehmbare Strömung zu erzeugen vermag.

C. ZUSAMMENSTELLUNG UND SCHLUSS

Die bewegende Kraft ist die Wärme. Der Wind entspricht der Steuerung der Dampfmaschine, die Verdunstung dem Schwungrad. Lage des Minimums.

16. Stellen wir nunmehr die für die oceanischen Strömungen in betracht kommenden Kräfte zusammen:

(*a*) *Die Verdunstung.*—Es ist zu unterscheiden die sofortige und die

[a] Annal. d. Hydrographie, 1904, S. 209, ff., Wendt.
[b] Hann; Allgemeine Erdkunde, 5. Aufl., Bd. I, S. 280.

säculare Wirkung. Erstere verleiht allem Wasser bis zur grössten Tiefe ein Gefälle von höheren Breiten zum Äquator. Letztere müsste eine umgekehrte Verticalcirculation zur Folge haben. Doch kommt eine solche im offenen Ocean nicht zu Stande, sondern es erfolgt zunächst nur eine Abschwächung des zweiten Factors, der Wärme.

(*b*) *Die Wärme* erteilt den unteren Schichten ein Gefälle zum Äquator, den oberen ein entgegengesetztes, und zwar letzteres so stark, dass sie den entgegenstehenden Einfluss der Verdunstung überwiegt und die sogennante Verticalcirculation hervorruft.

Beide Kräfte zusammen würden an der Oberfläche einen die ganze Breite der Oceane einnehmenden schwachen, kaum wahrnehmbaren Abfluss vom Äquator und einen unterseeischen, in den tiefsten Rinnen enger zusammengedrängten, vielleicht messbaren Zufluss zum Äquator bedingen.

(*c*) *Der Wind* verhindert in den östlichen Teilen der Oceane nicht nur den Abfluss des oberen Wassers, sondern überwiegt zunächst den Einfluss des Gefälles, sodass er hier im Verein mit der Wirkung der Verdunstung einen Zufluss zum Äquator und sodann die westlichen Äquatorialströme veranlasst. Wo diese auf zusammenhängende Landmassen stossen, häufen sich mächtigere Wasserschichten von geringer Dichte an, und ihr polwärts gerichtetes Gefälle wächst derartig, dass sie von den westlichen Teihen der Oceane aus, entgegen der Tendenz des Passats, abfliessen. Ihre hohe Temperatur ruft in dem Gürtel höchsten Luftdrucks, von dem die Passate ausgehen, eine so starke Auflockerung hervor, dass sich in ihm eine Furche niederen Druckes bildet, die den Passat nicht zu Stande kommen lässt. Hier kehrt sich also das Causalverhältniss um, und der Wind folgt dem warmen Strome.

Der Wind concentriert sonach gewissermassen das über die ganze Breite der Oceane verzettelte schwache Gefälle auf die westlichen Teile und ist für die Gestaltung der Oberflächenströme, auch des Golfstroms, ein durchaus wesentlicher Factor. Trotzdem bildet er nicht das primäre Motiv; sonst müsste eine unterseeische Strömung das in den Tropen, insbesondere im Golf von Mexiko aufgestaute Wasser von dort wegführen,[a] was nicht der Fall ist.

Somit spielt der Wind im Vergleich zur Wärme etwa die Rolle der Steuerung bei der Dampfmaschine. Die bewegende Kraft ist die Wärme; dass sie sich aber in der Weise äussert, wie es geschieht, dass die Wärmewirkung nach bestimmten Stellen hingelenkt wird, wo alsdann deutlich wahrnehmbare Bewegungen zustande kommen, bewirkt der Wind.

Und die Verdunstung ersetzt gewissermassen das Schwungrad. Sie tritt zunächst der Wirkung der Wärme entgegen, hemmt und verzögert sie. Aber das zurückbleibende salzreichere Wasser der Ober-

[a] Vgl.: Annal. d. Hydrographie, 1895, S. 456, ff Witte: Luft und Meeresströmungen.

fläche trägt die Erwärmung in tiefere Schichten und macht ihren Einfluss um so nachhaltiger.

(*d*) *Die Axendrehung der Erde* lenkt die Strömungen der nördlichen Halbkugel nach rechts, der südlichen nach links ab, soweit dies nach der Gestaltung der Festländer möglich ist. Die Richtung des Gefälles liegt also, wie bei den Luftströmen, auf unserer Hemisphäre nach vorn links, woraus z. B. für den Golfstrom folgt, dass sich an der Küste der Vereinigten Staater eine Depression der Oberfläche oder, in der Sprache der Meteorologie, ein langgestrecktes Partialminimum hinzieht.

Schluss.

17. Sonach bildet das Buys-Ballotsche Gesetz auch für die Bewegung der oceänischen Gewässer die Grundlage. Doch bedingt in nicht wenigen Fällen der Wind für die Oberfläche eine Abweichung, während der umgekehrte, nicht weniger mächtige Einfluss der Meeresströme auf den Wind immer mit dem Grundgesetz in Übereinstimmung bleibt.

ANHANG

Die Vorbedingung der Windtheorie. Dubuat's Gedankengang. Missbrauch seines Namens.

Die Lehre von der Erzeugung der Meeresströmungen ausschliesslich durch den Wind hat in den massgebenden Kreisen Deutschlands seit fünfundzwanzig Jahren die Alleinherrschaft. Die Theorie hat zur Voraussetzung, dass nicht andere, stärkere Einflüsse dem sehr lange Zeiträume erfordernden Eindringen der Windtrift in grössere Tiefen zuvorkommen. Zöppritz, der Urheber der Lehre, sagt ausdrücklich:[a] "Natürlich wird vorausgesetzt, dass keine andere Ursachen * * * die tieferen Schichten in andere Bewegungen versetzen."

Diese Voraussetzung glaubte Zöppritz erfüllt. Denn er meinte, dass ein Gefälle von weniger als $1 : 10^6$ keine Strömung des Wassers erzeugen könne, und stützt sich dabei auf Croll und Dubuat.[b] Croll aber beruft sich, wie sich zeigen wird, auf Dubuat. Da nun Dubuat's Werk[c] schwer zugänglich ist, will ich den Gedankengang dieses ausgezeichneten Forschers so kurz wie möglich angeben.

Dubuat behandelt ausschliesslich den Fall (§4): "Quand on oblige l'eau à passer par un tuyau fermé ou dans un canal ouvert, dont la section est constante, et la longueur assez grande pour que le mouvement y devienne uniforme." Beide Annahmen passen auf die Meeresströmungen nicht, da weder ihr Bett constant, noch ihre Bewegung gleichförmig ist. Lassen wir aber zunächst die Annahmen gelten, so

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[a] Annal. d. Hydrographie, 1878, S. 240.
[b] Oceanographie v. Krümmel, Stuttgart, 1887, Bd. II, S. 286.
[c] Dubuat: Hydraulique, Paris, 1816.

ist richtig, dass eine gleichmässige Geschwindigkeit auf die Dauer nur möglich ist, wenn die beschleunigenden und die verzögernden Kräfte gleich sind.

Die Beschleunigung ist $\frac{g}{b}$, wo g die Beschleunigung durch die Schwere bedeudet und $\frac{1}{b}$ das Gefälle. Dass Dubuat von der herkömmlichen Definition des Gefälles etwas abweicht, hat auf die weitere Betrachtung keinen Einfluss.

Die Verzögerung setzt Dubuat zunächst versuchsweise proportional dem Quadrate der Geschwindigkeit v, so dass dieselbe gleich ist $\frac{v^2}{m}$, wo m eine Constante bedeutet. Dann ist nach dem obigen Princip

$$\frac{v^2}{m} = \frac{g}{b}; v = \frac{\sqrt{mg}}{b}$$

Diese Formel vergleicht Dubuat mit den Ergebnissen der von ihm und andern angestellten höchst sorgfältigen Versuche.

Bei den Versuchen handelt es sich ausschliesslich, mit einer noch zu besprechenden Ausnahme, um Röhren vom Durchmesser 1½ Linien bis 18 Zoll und um einen künstlichen Kanal, dessen Boden und Wände aus je einem Brett von 18 Zoll Breite bestehen.

Der Vergleich ergibt, dass die Formel nicht stimmt, und so versucht es Dubuat, auf eine Reihe subtiler Betrachtungen gestützt, zunächst mit einer Function von b, in dem er statt $\sqrt{b}$ setzt $X = \sqrt{b} - l\sqrt{b}$, wo l den hyperbolischen Logarithmus bedeutet. Auch so stimmt die Formel unvollkommen, und "comme la théorie devient ici insuffisante, l'expérience seule a pu nous indiquer la vraie valeur de X." Er setzt also probeweise statt $l\sqrt{b}$ den Wert $l\sqrt{b} + c$. Über c sagt er: "En consultant l'expérience * * * on trouve qu'en effet c peut être supposé une quantité constante et égale à 1.6," so dass die Formel zunächst lautet

$$v = \frac{\sqrt{mg}}{\sqrt{b} - l\sqrt{b} + 1.6}$$

So ist endlich für eine und dieselbe Röhre die Formel mit den Versuchen in Einklang gebracht, nicht aber für Röhren von verschiedenem Radius. Es wird daher zunächst wieder versuchsweise die Constante m proportional dem mittleren Radius r der Röhre gesetzt, also $m = nr$. Dass auch so die Formel nicht stimmt, wird mit Recht auf die Adhäsion zurückgeführt, und daher versuchsweise von $\sqrt{r}$ eine Constante subtrahiert, die gleich 0.1 Zoll ermittelt wird. Es ist also jetzt

$$= \frac{\sqrt{ng}(r - 0.1)}{\sqrt{b} - l\sqrt{b} + 1.6}$$

Die Experimente ergeben $n = 243.7$, wenn alle Grössen, auch 0.1 und 1.6, in Pariser Zoll ausgedrückt sind.

Hierbei wird der mittlere Radius r folgendermassen ermittelt. Ist, wie bei einer Röhre, der Querschnitt ein Kreis vom Radius R, so ist sein Inhalt $R^2\pi$, sein Umfang, an dem die Reibung stattfindet, $2\,R\pi$, ihr Quotient $\frac{R}{2} = r$. Dem entsprechend setzt Dubuat für jedes Flussbett den Quotienten aus dem Querschnitt und dem Teile seines Umfanges, an dem die Reibung stattfindet, gleich dem mittleren Radius r, sodass z. B. für einen rechtwinkligen offenen Kanal von der Tiefe a und der Breite b sein würde $r = \frac{ab}{2a+b}$.

Die gefundene Formel stimmt nun aber wieder nicht bei der Anwendung auf weitere Röhren, noch weniger für den Kanal du Tard und das Flüsschen Haine an der belgisch-französischen Grenze, an denen Dubuat seine Beobachtungen macht. Darum nimmt er eine "viscosité" an und sucht diese Eigenschaft des Wassers zu begründen durch eine Betrachtung über Form und Glätte seiner kleinsten Teile. Dass die hierbei gemachten Annahmen in Widerspruch stehen mit dem, was man jetzt über Molecule weiss, will ich nicht weiter betonen. Auf diese Weise gelangt Dubuat zu der Vorstellung, dass infolge der Viscosität bei einem bestimmten Gefälle $\frac{1}{B}$ überhaupt keine Bewegung entsteht, mithin verloren geht die Geschwindigkeit

$$V = \frac{\sqrt{ng}(\sqrt{r} - 0.1)}{\sqrt{B} - l(\sqrt{B} + 1.6)}.$$

Sonach ist die wirklich zustande kommende Geschwindigkeit

$$v = (\sqrt{r} - 0.1)\left(\frac{\sqrt{ng}}{\sqrt{b} - l\sqrt{b} + 1.6} - \frac{\sqrt{ng}}{\sqrt{B} - l\sqrt{B} + 1.6}\right).$$

Die Bestimmung des zweiten Gliedes in der Klammer "exigerait des expériences très-délicates, et nous n'avons pu obtenir à cet égard qu'une simple estimation, qui sera cependant très-suffisante pour la pratique. En combinant toutes les expériences, nous avons vu qu'on peut faire

$$\frac{\sqrt{ng}}{\sqrt{B} - l\sqrt{B+1.6}} = 0.3^{\text{po}} \text{ environ,"}$$

so das sich schliesslich ergibt (§ 51):

$$v = \frac{\sqrt{ng}\,(\sqrt{r} - 0.1)}{\sqrt{b} - l\,\sqrt{b+1.6}} - 0.3\,(\sqrt{r} - 0.1)$$

wo die numerischen Ausdrücke Pariser Zoll bedeuten.

Die Bewegung muss hiernach aufhören, wenn das Gefälle so klein ist dass $\frac{\sqrt{ng}}{\sqrt{b} - l\,\sqrt{b+1.6}} = 0.3$ ist, was etwa für das Gefälle $\frac{1}{b} = \frac{1}{10^6}$ zut-

rifft. Und nun sagt Dubuat vorsichtig § 53: "Ainsi, on pourrait croire que la plus petite pente, qu'on puisse donner à un canal, pour que la vitesse soit sensible, serait 1 : 500,000." Dies Resultat genügt ihm für seine Zwecke, nämlich für die Anlage von Drainagen, Wasserleitungen und kleiner Kanäle.

Wie wenig es ihm auf eine genauere Bestimmung von B ankommt, sieht man besonders später (Bd. II, § 403) wo er, um das Gefälle des Canal du Tard zu messen, neben ihm einen kleinen Graben von 9 Zoll Breite und Tiefe und 240 Toisen Länge anlegt. Hierbei macht er nicht einmal den Versuch, den Graben das eine Mal von der einen und dann von der andern Richtung her zu füllen, wobei sich ja möglicher Weise ein Niveau-Unterschied ergeben hätte. Dass ein solcher an einem neunzölligen Süsswasserkanal angestellter Versuch freilich auch dann noch nicht für die Meeresströmungen ohne weiteres beweisend sein würde, brauche ich nicht erst zu sagen.

Dubuat's Theorie beruht also durchaus auf Versuchen im kleinen Massstabe; sie soll nur für praktische Zwecke, für die Anlage von Ent- und Bewässerungen dienen und Dubuat selbst sagt von ihr § 56: "Notre théorie ne sera, si l'on vent, qu'une probabilité raisonnée; mais du moins la nature paraît agir d'une manière qui lui est bien analogue."

Und diese Untersuchungen überträgt Croll ohne weiteres auf Meeresströmungen. Er sagt, indem er sich ausdrücklich unter Angabe der Seitenzahl auf die angeführte Stelle beruft:[a]

"Water flowing down an incline, however steep it may be, soon acquires a uniform motion. There must therefore be a certain inclination below which no motion can take place." Schon dies ist falsch und widerspricht der Darlegung Dubuat's; aber weiter: "Experiments were made by M. Dubuat with the view of determining this limit. He found that when the inclination was 1 in 500,000 the motion of the water was barely perceptible, and he came to the conclusion that when the inclination is reduced to 1 in 1,000,000 all motion ceases." Daraus folgert er dann, dass der Unterschied des specifischen Gewichtes keinerlei Einfluss auf die Bewegung der oceanischen Gewässer haben könne. Und ähnlich S. 133, sowie S. 183–184, wo er noch einmal betont: "The experiments of M. Dubuat prove that the force of the molecular resistance is greater than the force derived from a slope of 1 in 1,000,000."

Das ist die Grundlage, auf die Zöppritz und Krümmel sich stützen. Ich brauche dem kein Wort hinzuzufügen. Die Vorbedingung, unter der allein die Zöppritzschen Untersuchungen möglicher Weise Gültigkeit haben könnten, ist nicht erfüllt. Es liegt kein Grund vor, warum man nicht mit kleinen Gefällen rechnen sollte. Und damit wird das Eindringen der Windtrift in grosse Tiefen hinfällig.

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[a] Croll, James: Climate and Time, London, 1875, S. 120, sowie S. 183 und 184.

LES TRAVAUX OCÉANOGRAPHIQUES DE SON ALTESSE SÉRÈNE LE PRINCE DE MONACO

Par J. THOULET, Nancy France

C'est une tâche sérieuse que d'avoir à vous exposer tous les travaux océanographiques qui ont été accomplis par Son Altesse Sérène le Prince Albert I de Monaco ou sous ses auspices. Ils ont commencé en 1885 et se sont continués sans interruption depuis vingt ans. Ils concernent la géographie, l'océanographie pure, l'étude des courants sous-marins et surtout la zoologie dans toutes ses branches. En ce moment même, le prince est en mer, dans les parages du cap Vert, s'occupant d'expériences d'une importance si particulièrement considérable qu'elles l'ont empêché, comme il en avait caressé le désir, de venir ici assister au Huitième Congrès géographique international. Cette année, en effet, et peut-être en vue de prochaines explorations polaires, il ajoute à ses travaux d'océanographie et de zoologie d'autres recherches concernant la météorologie, cette océanographie de l'océan atmosphérique. Or, je ne suis, hélas! ni zoologiste ni météorologiste. Il a exploré la plus grande partie de l'est de l'Atlantique septentrional, les Açores, les parages de Terre-Neuve, ceux du Portugal, de Madère, du Maroc, des Canaries, des îles du cap Vert, puis le golfe de Gascogne, au sud certains points de la Méditerranée, au nord la côte de Norvège, le Spitzberg. Or, je n'ai eu l'honneur d'accompagner Son Altesse qu'autour de Madère, des Canaries, du cap Vert et, l'année dernière, dans le golfe de Gascogne. À Monaco, il élève un immense et magnifique palais, un musée océanographique dont la première pierre a été posée le 25 avril 1899 et qui est destiné à abriter non seulement plusieurs laboratoires, tous les modèles d'instruments employés par lui dans ses campagnes, tous les types d'outils possédant un intérêt historique et ayant pu contribuer aux progrès de la science de la mer, non seulement les innombrables collections rapportées de ses voyages et qu'il augmente sans cesse, animaux au corps énorme comme les cétacés qu'il capture, les orques, les requins, tous ces géants de la mer, non seulement les poissons qui peuplent les profondeurs, mais encore les êtres les plus petits—plankton, nekton et benthos—qui habitent aussi

bien les eaux superficielles que les abîmes les plus profonds, si petits que les plus forts grossissements du microscope sont indispensables pour les apercevoir. On voit dans ce musée des échantillons du sol sous-marin depuis les roches erratiques ramenées par le chalut dans l'Atlantique nord, à la latitude de Brest et qui ont été charriés à la place où on les recueille par les blocs de glace, les icebergs détachés des glaciers qui à l'époque glaciaire couvraient l'Angleterre, la Scandinavie et tout le nord de l'Europe comme ils recouvrent aujourd'hui le Groënland, jusqu'aux vases fines du fond, faites de foraminifères, globigérines, orbulines, radiolaires, spicules d'éponges, algues calcaires dont les géants ont un peu moins de 1 millimètre de diamètre et de grains minéraux que je me suis amusé à peser et dont il faut environ 20,000 pour 1 milligramme. Voilà ce dont j'ai à vous entretenir. Je serais moins embarrassé si j'avais une douzaine d'heures devant moi au lieu des courtes minutes qui me sont accordées. Parmi tant de choses que je pourrais vous apprendre, vous expliquer, vous montrer, il me faut choisir, et là est la difficulté.

Le premier bâtiment monté par le prince de Monaco, qui n'était alors que prince héréditaire, était une goëlette de 200 tonneaux, *l'Hirondelle*, montée par une quinzaine de marins. C'était au début, tout à créer—que dis-je—à inventer; on était à peine renseigné sur les énormes difficultés à vaincre. Pour les pénibles manœuvres de la navigation et des recherches on ne possédait pas les puissantes ressources de la vapeur. Rien que des voiles et des bras humains. Ce fut une rude besogne que celle qui s'accomplit pendant les quatre campagnes de 1885, 1886, 1887 et 1888, principalement du côté de Terre-Neuve et aux Açores. On sonda, on lança des flotteurs destinés à indiquer la marche des courants superficiels, on dragua, on descendit le chalut jusqu'à 2,870 mètres. Pour cette opération, il fallut près de treize heures pendant lesquelles les hommes travaillèrent sans relâche alors que maintenant, avec la vapeur, il suffirait à peine de cinq heures.

En 1891, le prince fit construire un nouveau yacht, la *Princesse-Alice I*, trois-mâts goëlette de construction composite, jaugeant 600 tonneaux, muni d'une machine auxiliaire de 350 chevaux, mesurant 52.60 mètres de longueur totale, 8.20 mètres de largeur et 3.75 mètres de tirant d'eau. Le navire, pourvu de tout le matériel nécessaire et de véritables laboratoires, servit pour les campagnes annuelles de 1892 à 1897, inclusivement.

En 1897 le prince voulut mieux encore afin de faire plus encore. On mit sur le chantier la *Princesse Alice II*, magnifique navire en acier, à deux mats, gréé en goëlette, mesurant 73.15 mètres de longueur, 10.40 mètres de largeur, jaugeant 1,420 tonneaux, d'un tirant d'eau moyen de 4.50 mètres, capable de prendre 245 tonnes de charbon, muni de deux chaudières et d'une machine à triple expansion de 1,000 chevaux permettant d'atteindre une vitesse de 13 nœuds.

Je n'ose me lancer dans la description détaillée de ce palais flottant des sciences de la mer à bord duquel j'ai eu deux fois l'honneur de naviguer. Outre les appartements particuliers de Son Altesse, les chambres des invités, celles du personnel scientifique embarqué et les logements de l'état-major et de l'équipage, on y trouve tout ce qui sert a l'étude: laboratoire intérieur éclairé par cinq vastes hublots et une claire-voie, laboratoire du pont, chambre des cartes, laboratoire de photographie, partout éclairés la nuit au moyen de l'électricité; énormes treuils autour desquels s'enroulent des câbles en fils d'acier de 1,200 mètres de longueur et dont une partie formée de 72 fils d'acier galvanisé, arrangés en 6 torons de 12 fils, d'un diamètre de 14 milimètres. Ce câble présente une résistance de 7,000 kilogrammes et permet de draguer aux plus extrêmes profondeurs. Je l'ai vu traîner le chalut par 6,035 mètres de fond. Je passe sous silence la machine à sonder actionnée par la vapeur, les appareils et outils de toute espèce, dragues, chaluts, nasses, palancres, filets, plombs de sonde, tubes à recueillir les échandillons du fond, bouteilles à récolter de l'eau aux diverses profondeurs, instruments scientifiques, provisions et le reste.

Beaucoup de savants ont été embarqués sur la *Princesse Alice*—anglais, allemands et français, les uns d'une façon régulière, faisant partie de l'état-major scientifique du bâtiment, comme le docteur Richard, directeur du Musée océanographique de Monaco, le dévoué collaborateur du prince; les autres pendant une ou plusieurs campagnes—zoologistes, physiologistes, météorologistes et physiciens—profitant d'une hospitalité aussi large que bienveillante et des splendides installations du yacht pour élucider quelque point spécial de leur science particulière en rapport avec l'océanographie. Le travail est incessant sur le bâtiment et même en cours de route, il est bien rare que les observations s'arrêtent. On sonde, on recueille des échantillons du sol sousmarin, des eaux à diverses profondeurs qui seront analysés au retour, on mesure des séries de températures; puis, on pêche, on traîne le chalut, on envoie sur le fond des nasses qu'on relève deux ou trois jours après leur immersion, observatoires fixes destinés à rendre dans l'avenir des services encore à peine soupçonnés; on installe des palancres, on capture des animaux marins par tous les procédés connus ou qu'on invente au fur et à mesure que les besoins s'en font sentir—chalut de surface, filet Buchet, filets bathypélagiques, à rideau, tramail; haveneaux aux longs manches de bambou destinés à saisir pendant que l'on est en marche les animaux flottants passant à portée le long du bord. Un service est installé pour la pêche des grands cétacés, baleinières avec fusil porte-amarres à pivot pour envoyer le harpon, l'outillage complet indispensable a ces pêches, y compris un maître baleinier écossais chargé, sous la haute direction du prince, du soin du matériel et des opérations.

Le temps m'est trop réservé pour que je puisse entrer dans le

détail plus circonstancié des nombreux auvaux qui ont été exécutés à bord de la *Princesse Alice*. On en trouvera les résultats complets accompagnés de superbes gravures noires ou colorées dans le recueil des mémoires publiés aux frais du prince a Monaco et rédigés par les spécialistes auxquels ont été remis les spécimens rapportés et qui les ont étudiés dans le calme et le loisir de leurs laboratoires. Ce que j'ai dit suffira certainement pour montrer les éminents services qu'a rendu à la science depuis vingt ans celui qui m'a fait le grand honneur de me charger de le représenter au Huitième Congrès géographique international. Nulle part, j'en suis convaincu, ils ne seront mieux appréciés que dans le pays de Franklin qui découvrit en quelque sorte le Gulf-stream, de Maury, de Brooke, de Sigsbee, de Pillsbury, de Agassiz, du comte de Pourtalès et de tant d'autres marins, ingénieurs et savants qui, à bord de tant de vaisseaux, sous les plis flottants du pavillon étoilé, le *Dolphin*, le *Gettysburg*, l'*Essex*, le *Saratoga*, le *Blake*, l'*Enterprise*, le *Rush*, la *Jeannette*, l'*Albatross* et tant d'autres, ont étudié glorieusement l'océan depuis les glaces du pôle arctique jusqu' à celles du pôle antarctique en passant par les mers tropicales qui baignent les îles de corail de leurs flots attiédis.

ATLAS OCÉANOGRAPHIQUE DE L'ARCHIPEL DES AÇORES

Par J. THOULET, Nancy, France.

Les cartes et, d'une façon générale, les graphiques sont d'une utilité capitale en océanographie et l'on affirmerait volontiers que le but de toute investigation, de toute étude océanographique doit être de dresser de pareils documents avec une précision suffisante pour que leur examen et leur comparaison mutuelle permettent à chacun de lire aisément les lois qui y sont écrites.

La première qualité d'une carte est d'être claire. Pour cela elle doit être aussi simplifiée que possible et, afin de montrer plus nettement ce qu'elle doit montrer, ne se rapporter qu'à un seul objet, ne prétendre à mettre en lumière que les variations d'une unique variable. Rien n'est plus dangereux qu'une carte surchargée masquant ou tout au moins compliquant un sujet sous le détail d'un autre sujet. Il est de beaucoup préférable d'en multiplier le nombre. La dépense de temps est moindre qu'on ne serait tenté de se l'imaginer car, sur toutes les cartes marines, le canevas de Mercator est presque aussi aisé à dresser qu'à calquer et les contours précis des terres, d'importance d'ailleurs assez secondaire, toujours les mêmes pour une même région, sont susceptibles d'être rapidement reproduits. La besogne n'offre aucune difficulté au dessinateur. C'est dans ce même but de clarté maximum qu'on aurait tort de s'effrayer de l'emploi des couleurs vives. La loi à découvrir résultant d'une opposition de phénomènes, plus sera marquée l'opposition des teintes représentant les phénomènes et leurs gradations, plus aura chance d'éclater aux yeux l'opposition des phénomènes eux-mêmes, et par conséquent la loi. En résumé, simplicité et clarté, tels doivent être les caractères essentiels des graphiques et des cartes océanographiques.

La seconde qualité à exiger est l'unité d'échelle et de région. Les cartes ou mieux leurs calques sont destinés à être superposés les uns aux autres. Aucun procédé de comparaison n'est préférable à celui de la superposition. On comprend donc l'obligation impérieuse de figurer à plusieurs exemplaires la même région et de la même façon. Les phénomènes représentés seuls différeront.

Le troisième point est une entente préalable complète sur le mode de représentation. La tâche des congrès internationaux est de provoquer cette entente. La connaissance de l'océan est une œuvre de longue haleine et d'infatigable patience. Il faut, puisque tous les travailleurs du monde sont conviés à participer à la besogne, qu'aucun d'eux ne perde une partie du temps précieux qu'il entend consacrer à cette gigantesque œuvre commune à se mettre au courant des travaux de ses prédécesseurs, à coordonner et à unifier les résultats déjà obtenus par eux afin de les reproduire sous une forme différente et y ajouter ensuite la somme de ses propres résultats toujours faible puisqu'elle n'est que le total du labeur d'un seul. La bibliographie d'une question ne doit guère consister qu'en une carte datée et l'indication du travail restant à accomplir se bornera au remplissage de blancs d'après des méthodes identiques à celles déjà employées.

Telle est la raison pour laquelle il importe sous peine de perdre dans l'avenir une énorme somme d'efforts, de s'entendre dès le début sur les méthodes de mesure des phénomènes et les modes de représentation.

Les premières cartes à établir sont celles destinées à représenter la topographie, le relief du sol sous-marin. Elles sont la base indispensable de tout ce qui sera fait ultérieurement. Grâce à la générosité du Prince de Monaco, le travail est achevé. L'échelle initiale de la carte générale des océans a été fixée au 1/10,000,000e et l'on a admis le principe des échelles sous-multiples comme le 1/1,000,000,e le 1/100,000e et même moins et les sous-multiples simples de ces sous-multiples comme le 1/500,000e et le 1/50,000e. On en dirait autant du mode de représentation par aires isobathes teintées en bleu d'autant plus foncé que la profondeur augmente davantage. Mais, comme l'a depuis longtemps conseillé le Dr. F. A. Forel pour les lacs suisses, il importe que le rendu lui-même signale à chaque instant le degré de confiance devant lui être accordé. Comme une carte doit être dès le début complète, elle devra porter, sur le sujet particulier qu'elle traite, toutes les indications non contredites alors même que certaines lignes ou certaines portions d'une même ligne ne mériteraient pas toujours même confiance. Un exemple fera mieux comprendre. Entre deux sondages éloignés impliquant, par la différence de leurs côtes, deux ou trois isobathes intermédiaires, il n'y aura pas lieu d'hésiter à tracer ces lignes quand même la position rigoureuse de chacune d'elles serait inconnue, et par conséquent leur représentation susceptible d'être peu exacte parce que le fait qu'elles sont au nombre de deux porte déjà à lui seul son enseignement. Si l'on prend la résolution de marquer chaque sondage par un point, il est évident que sur la carte générale, une région criblée de points inspirera et méritera plus de confiance qu'une autre où les points seront éparpillés et non moins évident que quiconque aura l'intention de perfectionner la carte générale, n'ira pas, sans motifs sérieux, user son temps à retravailler la région criblée de points

et ne manquera pas de s'occuper immédiatement de celles où les points sont clairsemés.

En tous cas, les cartes dressées aux frais du Prince de Monaco résolvent la question. Les cartes parfaites du fond de l'océan qui existeront dans un ou deux siècles, seront les mêmes que celles que, grâce à lui, nous possédons aujourd'hui et sur lesquelles les océanographes, sans rien inventer de nouveau et uniquement à force de travail, de bonne volonté et de conscience, auront encore travaillé pendant une ou deux centaines d'années. C'est un immense édifice dont le plan est dès à présent établi d'une manière immuable et qu'élèveront lentement, jusqu'à achèvement complet, générations de travailleurs après générations de travailleurs.

La question des cartes bathymétriques étant réglée, il semble que les plus pressés parmi ces documents soient, après elles, d'abord les cartes lithologiques destinées à résoudre tant de problèmes immédiatement applicables à la géologie ancienne. Viennent ensuite celles relatives à la distribution de la température, car leurs applications pratiques sont impatiemment attendues par l'industrie des pêches et celle de la télégraphie; puis les cartes des densités S^0_4 et S^θ_4 qui apporteront les moyens d'élucider l'économie de la circulation océanique; enfin les cartes de courants. Peut-être dressera-t-on dans la suite des cartes de répartition des halogènes et de l'acide sulfurique à la surface et dans les profondeurs, sans compter les cartes qui résulteraient d'un problème scientifique nouveau quelconque et qui devra, lui aussi, être représenté graphiquement.

La nécessité de cartes lithologiques s'aperçoit immédiatement: elles correspondent aux cartes géologiques terrestres et, si l'utilité théorique est aussi grande pour les unes et les autres, qui sait si l'utilité pratique pour les pêcheurs, les marins et les ingénieurs, grâce à l'emploi de la méthode du comte de Roujoux, ne l'emporte pas pour les cartes lithologiques marines? Du reste, leur mode de représentation est le même. Il consiste en un coloriage très heurté des cartes bathymétriques par aires de sol de nature lithologique semblable. Il est indispensable qu'elles soient dressées d'après des principes parfaitement établis et toujours les mêmes. C'est ce que je me suis efforcé de faire en proposant une classification générale des fonds marins, un procédé d'analyse mécanique et minéralogique des sédiments et en publiant les 22 feuilles de mon atlas bathymétrique et lithologique des côtes de France. Ce travail, qui n'est qu'une esquisse, servira à illustrer la méthode. J'ai pointé les localités dont j'étais sûr parce que j'en avais analysé les échantillons. Sans méconnaître leur nombre malheureusement trop restreint, je n'ai pas hésité à remplir de teintes tout l'espace blanc des feuilles d'après des données douteuses. Un document qui n'est qu'à demi exact, sans toutefois faire mystère de son imprécision, qui montre les points à améliorer et indique par cela

même les moyens d'y parvenir, vaut mieux, puisqu'il existe, qu'une perfection qui n'existe pas. Créons d'abord et ensuite perfectionnons ndéfiniment sans jamais nous lasser. Que d'autres continuent la tâche que j'ai entreprise et travaillent au moyen de recherches directes, coin de mer par coin de mer, à améliorer mes feuilles. La récolte et l'analyse d'un seul échantillon, dans la Manche, dans l'océan Atlantique ou dans la Méditerranée, la détermination de sa nature selon les règles qne j'ai énoncées, le pointage sur la carte de la toute petite modification que cet échantillon entraîne, sera un progrès. Il suffira de répéter les opérations cent, mille ou dix mille fois pour avoir le monument que sera la carte lithologique d'une région comme la France maritime et de multiplier à son tour ce monument cent ou mille fois par lui-même pour avoir celui, plus splendide encore, de la carte lithologique sous-marine du globe. Si la vie de l'homme est courte, l'humanité possède des siècles devant elle. Aller vite vaudrait mieux, mais après tout il importe assez peu de marcher lentement pourvu qu'on avance d'une manière assurée et continue.

Les cartes lithologiques sont susceptibles d'offrir une variété infinie. Il dépend de chaque auteur de chercher à mettre tel ou tel fait particulièrement en évidence graphique: grosseur des grains, présence et répartition de quelque minéral spécial, proportion de calcaire. L'essentiel est que toutes ces cartes soient exécutées d'après les mêmes principes.

Pour les cartes physiques, celles de la distribution de la température, des densités, ou pour les cartes mécaniques comme celles des courants, je préconiserai l'emploi de la méthode des plans parallèles. Voici en quoi elle consiste:

La plupart des phénomènes de la mer ont lieu non seulement en plan mais dans l'espace. Un courant est un fleuve qui, différent en cela d'un fleuve continental coulant à plat sur le sol, est une colonne liquide pénétrant dans la masse des eaux qui l'environnent, en montant ou en descendant. On le comparerait à quelque veine ou à quelque artère à trajet sinueux du corps d'un animal. Pour reconnaître ce trajet, si 'animal est impossible à disséquer, les zoologistes, avec un microtome, découpent son corps en une infinité de plans parallèles dont l'orientation réciproque est soigneusement repérée. Ces plans examinés méthodiquement au microscope et convenablement superposés permettront de reconstituer la veine ou l'artère dans l'espace avec toutes ses circonvolutions.

L'océanographe procédera pareillement. Une masse d'eau d'un caractère déterminé, physique ou chimique, ayant même température, même densité, même teneur en halogènes ou en acide sulfurique, ne constitue pas une nappe mince uniformément répandue horizontalement au sein des eaux océaniques. Elle a ses bords limités, monte et descend, est un volume et non pas un plan. Dans ces conditions, on ne se rendra

compte de son existence et de ses circonvolutions que par une série de plans parallèles à la surface de la mer, espacés entre eux de distances connues, 100 mètres ou 1,000 mètres, qui sectionneront le volume à étudier et permettront de distinguer à divers niveaux son aire d'intersection et par conséquent d'établir sa forme et ses dispositions. J'ai ainsi dressé la carte à 1,000 mètres de profondeur de la température de la mer dans la région des Açores afin de montrer le mode de rendu que j'ai adopté dans l'intention d'obtenir la clarté maximum. Que l'on suppose une demi-douzaine de ces cartes de la même région espacées, par exemple, de 500 en 500 mètres les unes des autres, chacune avec un plus grand nombre de points que je n'ai—hélas!—pu en placer; les aires isothermes étant délimitées par des courbes isothermes et coloriées en rose carmin d'autant plus foncé que la température de l'eau est plus chaude, en superposant ces plans ou leurs calques respectifs, on aura l'indication parfaitement exacte et indiscutable de la répartition de la température dans la masse entière des eaux de la région.

Un avantage sérieux de pareils documents sera de montrer aussi nettement l'œuvre déjà accomplie que l'œuvre restant à accomplir. Je connais assez bien, depuis le temps que je m'en occupe, la région des Açores, et cependant, si l'on m'avait demandé combien de localités à températures se trouvaient dans le plan de 1,000 mètres de profondeur, j'aurais certainement répondu qu'il n'y en avait pas beaucoup, mais jamais je n'aurais pensé qu'en faisant le total de toutes celles récoltées par le *Challenger* et par la *Princesse Alice*, jamais avant de l'avoir constaté de mes yeux, je n'aurais supposé qu'il n'y en avait que cinq! Le meilleur éducateur d'un océanographe est la carte qui lui dit la vérité, le félicite sincèrement de ce qu'il a fait et lui indique non moins sincèrement, quelquefois même brutalement, comme dans le cas actuel, ce qu'il lui reste à faire.

Les considérations relatives aux cartes de températures s'appliquent mot pour mot à toutes les autres cartes physiques ou chimiques, quelles qu'elles soint. La couleur des aires seule différera: le rouge carmin servira pour la température, la sépia pour le calcaire, telle ou telle autre couleur pour telle ou telle autre propriété. Le premier qui exécute un travail a le droit de prendre une couleur parmi celles qui n'ont pas encore été utilisées et ceux qui viennent après lui, sauf raisons majeures et plus que majeures, ont le devoir de l'imiter s'ils poursuivent les mêmes études.

Le document servant de point de départ pour dresser ces cartes est la station avec toutes ces caractéristiques dont chacune est représentée graphiquement. Nous avons parlé de l'avantage de la netteté, celui de la continuité est aussi important. Après avoir recueilli sept ou huit échantillons d'eau convenablement espacés en une même localité, en série verticale entre le fond et la surface, après les avoir analysés et

avoir représenté par une ou plusieurs courbes les divers résultats obtenus, on aura aux profondeurs données la représentation certaine des valeurs de la variable et, avec les meilleures probabilités d'exactitude, toutes les valeurs intermédiaires. Il est évident que la certitude n'en sera pas absolue. Une irrégularité locale est susceptible de se présenter et de passer inaperçue. Malgré la justesse de l'objection, il est impossible de procéder autrement; on a fait pour le mieux. La découverte complète de la vérité n'est qu'une suite d'approximations. Pour chaque station on construit la courbe des θ, celle des S°_{4}, des S^{θ}_{4}, des halogènes et de l'acide sulfurique et l'on conserve chacun de ces documents qui est, en quelque sorte, l'état civil de la station. Je tiens ceux que je possède à la disposition de quiconque voudra s'en servir pour continuer mes travaux et, quant au reste, je m'en remets au temps.

Une dernière recommendation. Si la science a pour but la découverte de lois générales, le savant ne peut procéder que par faits particuliers qu'il n'a chance d'élucider qu'en les prenant un a un. Cependant le cas particulier n'est jamais qu'un acheminement vers la généralisation; pris en soi et restant simple cas particulier, sa valeur est bien faible. Etudions la nature des fonds, la distribution du calcaire, celle de la température ou de la densité ou de toute autre variable en France, aux Açores, dans l'Atlantique nord ou ailleurs, mais ne cessons pas d'avoir en vue l'océan.

Les considérations qui précèdent m'ont guidé dans la confection d'une série de cartes dont la réunion, quel qu'en soit le nombre, est destinée à constituer un atlas océanographique de l'archipel des Açores.

1. CARTE BATHYMETRIQUE

La carte au 1/1,000,000[e] est par conséquent à une échelle décuple de celle de l'atlas général bathymétrique de l'océan du prince de Monaco. Elle a été dressée principalement d'après les sondages exécutés par le prince, tant à bord de *l'Hirondelle* que de la *Princesse Alice* et d'après ceux du *Britannia* rapportés sur la carte jointe au mémoire de MM. Peake et John Murray.[a] On a indiqué tous les sondages dépassant 1,000 mètres et supprimé un grand nombre de sondages n'atteignant pas cette profondeur et voisins des terres. On les trouvera sur la carte au 1/1,000,000[e] dont la seconde édition a été publiée par le prince.[b] Ils auraient été trop serrés à l'échelle adoptée.

En examinant cette feuille, on est frappé immédiatement des lacunes qui se présentent en mer profonde. Le plateau supportant les

[a] On the results of a deep-sea sounding expedition in the North Atlantic during the summer of 1899, by R. E. Peake, with notes on the temperature observations and depths, and a description of the deep-sea deposits in this area, by Sir John Murray. Royal Geographical Society, 1901.

[b] Carte bathymétrique des îles Açores d'après les cartes françaises et anglaises, etc., par M. J. Thoulet, corrigée d'après les sondages exécutés en 1902 par la *Princesse Alice* et les travaux les plus récents, 1903.

sept îles orientales du groupe offre trois lacunes particulièrement importantes, au nord-est d'une ligne joignant Terceira à Graciosa, au nord-ouest de la ligne Fayal-Graciosa, et au sud de Terceira où un seul sondage à 2,419 mètres implique l'existence d'une fosse assez profonde. Dans les fonds dépassant 1,500 mètres, l'espace océanique compris entre les sondages en ligne droite relatifs aux trois lignes télégraphiques joignant Fayal à l'Irlande, à l'Allemagne, a New-York et à la Nouvelle-Ecosse est à peu près vide. Toute une bande dirigée de l'est à l'ouest et située au sud de l'archipel manque absolument de données topographiques et les isobathes y sont tracées d'une manière hypothétique. Je signalerai aussi comme faisant défaut la bathymétrie précise de l'intérieur du vaste cratère hémi-circulaire, s'ouvrant au sud, dont les deux extrémités sont marquées par Santa Maria à l'est et par la pointe méridionale du banc de la Princesse Alice, à l'ouest. Le banc assez vaste limité par l'isobathe de 1,500 mètres et surmonté de trois pics sous-marins, situé entre Fayal et Florès, est suffisamment indiqué. Il serait assez juste de le désigner sous le nom de banc du Britannia; en revanche, le banc de Florès n'est étudié que dans ses portions méridionale et orientale; sa partie occidentale ne possède pas un seul sondage.

Un fait remarquable est l'aspect entrêmement accidenté du fond au-dessus de l'isobathe de 1,500 mètres. Partout le sol est semé de pics isolés aux flancs abruptes ou de caldeiras à pentes rapides sans relations mutuelles. Il en résulte un modèle général assez analogue à celui d'un paysage lunaire ou, pour prendre un exemple moins loinstain, à celui de la région des champs Phlégréens, en Italie. Les sept îles orientales sont les sommets émergés d'un immense cratère se dressant sur un socle limité par l'isobathe de 1,500 mètres et dont les pentes sont hérissées de cratères et de cônes adventifs cachés sous les eaux, y compris l'énorme dépression de 3,329 mètres de profondeur maximum constituée par la fosse de l'*Hirondelle*.

J'ai porté sur la carte quelques sondages très récents dont je dois communication à l'obligeance du comte Chaves, directeur du Service météorologique aux Açores. Un premier groupe exécuté par le *Mirror* en mars 1903, indique un plateau surélevé par deux pics, dans le sud de Terceira; un second groupe, dû au *John Pender* en mai 1904, fixe la position de deux pics plus petits, sur le bord occidental de la fosse de l'*Hirondelle*. J'ai aussi noté l'emplacement où, à l'extrémité nord-ouest de l'île de São Miguel, en face de la pointe Ferraria, à environ 1¼ milles de terre, par 40 brasses de fond, apparut le 18 juin 1811 l'ile volcanique de Sabrina qui disparut trois mois après. On trouvera de précieux détails sur cette éruption dans le recueil intitulé "Archivo dos Açores."[a]

[a] Archivo dos Açores, Vol. V, No. XXIX, Ponta Delgada, Ilha de São Miguel, 1884.

Sur la feuille au 1/400,000ᵉ des cinq îles centrales des Açores, où sont indiquées les isobathes de 100 en 100 mètres, on reconnaît encore mieux l'irrégularité de la répartition des coups de sonde. On comprend donc la nécessité de déterminer au plus tôt, à la mer, au moins quelques profoundeurs sur les espaces non remplis et de reporter immédiatement sur le papier les résultats trouvés dont un seul, convenablement placé, entraîne souvent des modifications importantes dans une série entière d'isobathes.

2. CARTE DE LA DISTRIBUTION DU CALCAIRE SUR LE FOND

Cette carte exécutée d'après 67 analyses d'échantillons de fonds, comporte cinq zones, colorieés de couleur sépia, en teintes augmentant d'intensité avec la teneur croissante en carbonate de chaux: I, sans calcaire; II, de 5 à 25 pour cent; III, de 25 à 50 pour cent; IV, de 50 à 75 pour cent, et V, de 75 à 100 pour cent de calcaire. Les dosages ont été exécutés par sir John Murray sur quelques échantillons provenant du *Challenger* et du *Britannia*[a] et, pour la plus grande partie, par moi-même sur des fonds récoltés par le prince de Monaco et confiés par lui au laboratoire de Nancy. La carte montre nettement, qu'au moins dans le voisinage des Açores, le pourcentage de calcaire augmente avec la profondeur.

L'intérêt d'un pareil document convenablement complété est considérable. Il trouve des applications immédiates en géologie et tend à éclairer la génèse des couches anciennes de calcaire, jadis fonds marins et maintenant inondées.

La proportion de carbonate de chaux contenu dans un fond est en effet la somme algébrique d'un apport et d'une destruction. L'apport est principalement dû à des foraminifères vivant à la surface des eaux et tombés sur le fond après leur mort. Comme ces êtres sont particulièrement abondants au milieu des eaux chaudes, leurs dépouilles doivent jalonner la projection sur le lit océanique du parcours des courants chauds à la surface. Tel est le cas pour le Gulf stream. Si l'avenir, grâce à des cartes analogues mais plus complètes, confirme la loi d'accroissement simultané de la proportion du carbonate de chaux et de la profondeur, comme la température décroit, elle aussi, avec la profondeur, le phénomène ne serait-il pas dû, au moins en partie, à la solubilité moindre du calcaire dans les eaux froides du fond que dans les eaux chaudes de la surface? Il serait à désirer, pour les besoins de l'océanographie, qu'un physicien dressât le tableau de la solubilité à diverses températures et sous diverses pressions, du carbonate de chaux dans l'eau de mer.

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[a] Peake et Sir John Murray, loc. cit.

3. CARTE DE LA DISTRIBUTION DE LA TEMPÉRATURE AU FOND.

Cette carte a été dressée d'après 37 mesures de températures prises à bord du *Challenger*, du *Britannia* et surtout de la *Princesse Alice*. La disposition des isothermes s'accorde assez bien avec l'hypothèse de la solubilité du calcaire moindre dans les eaux froides que dans les eaux chaudes. La température décroit avec la profondeur du fond. L'océan serait-il donc au point de vue de la répartition de la température dans la masse de ses eaux comme un ensemble de cuvettes accolées, tantôt complètement isolées jusqu'à une certaine hauteur, tantôt en communication plus ou moins parfaite les unes avec les autres. L'eau en contact avec le fond est la plus froide et dans les cuvettes isolées elle se maintient complètement immobile. À mesure que les couches se rapprochent de la surface, elles dépassent les bords des cuvettes, communiquent entre elles selon la topographie du sol et s'étendent horizontalement sur un plus vaste espace. Bien que leur température augmente alors à peu près régulièrement dans le sens vertical, elle tend à s'égaliser dans le sens horizontal jusqu'au moment où, franchissant par 1,000 mètres de profondeur la limite des eaux profondes calmes et des eaux improfondes agitées, les courants et le climat aérien commencent à leur faire éprouver de grandes variations thermiques dans le sens horizontal. Le coin thermique polaire ne se faisant d'ailleurs sentir que sur le pourtour des régions glacées, à une très faible profondeur, n'est qu'un cas particulier local. La solution, quelle qu'elle soit, de la question se manifestera nettement aux yeux aussitôt qu'on possédera des cartes suffisamment précises et étendues du relief du fond et de la distribution de la température. L'utilité pratique de pareilles cartes est considérable en télégraphie sous-marine.

4. CARTE DE LA DISTRIBUTION DE LA TEMPÉRATURE À 1,000 MÈTRES DE PROFONDEUR

Ainsi que nous l'avons dit plus haut, le plan horizontal de 1,000 mètres de profondeur est la limite séparant les eaux abyssales des eaux improfondes caractérisées les unes et les autres par un ensemble de caractères distinctifs différents, parmi lesquels le plus important est certainement l'immobilité d'une part, la mobilité de l'autre, avec les conséquences qu'elles entraînent. À ce titre il convient de connaître la distribution de la température dans ce plan. Malheureusement les données que possède la science à ce sujet sont peu nombreuses et la carte a le mérite d'en fournir une preuve qui n'est que trop frappante. Elle ne porte en effet que cinq points, trois provenant du *Challenger* et deux de la *Princesse Alice*, et encore parmi celles-ci il en est une, la station 1324, la plus orientale, indiquant une température de 9°, qui, à cause de l'énorme écart de 2° environ qu'elle présente avec les quatre

autres, mérite d'être tenue en suspicion. Une série verticale d'échantillons d'eaux avec leurs températures respectives, permet de se rendre compte de la circulation océanique. À défaut d'une série complète, évidemment préférable, il serait à désirer qu'on pût au moins prendre trois échantillons d'eaux avec leurs températures, dans le plan de 1,000 mètres et dans ceux qui l'encadrent à 100 mètres au-dessus et au-dessous, c'est-à-dire à 900 et à 1,100 mètres. L'opération à la mer n'exigerait pas un temps considérable. On pourrait même, à la rigueur, l'abréger en ne prenant de l'eau avec sa température qu'à 1,000 mètres. Ces données suffiraient pour établir le S°_{4} et le S^{θ}_{4} et l'on aurait au moins la direction des courants très lents susceptibles de régner dans le plan limite.

5. CARTE DE LA DISTRIBUTION DE L'AMMONIAQUE TOTALE DANS LES FONDS

On admet que la matière organique contenue dans les fonds réagit par son ammoniaque sur le sulfate de chaux en dissolution dans les eaux marines pour donner naissance à du carbonate de chaux. Celui-ci, précipité chimiquement, serait peut-être le ciment unissant entre eux les débris incohérents calcaires tombés de la surface et amoncelés sur le fond, contribuant à les transformer en masse compacte et à produire ainsi le calcaire massif tel que nous le voyons dans les couches géologiques autrefois fonds de mer et aujourd'hui émergées. La question offre une réelle importance. Tel est le motif qui m'a conduit à dresser cette feuille d'après les analyses faites à Nancy, de 40 échantillons recueillis par la *Princesse Alice*. J'ai établi quatre catégories de teneur en ammoniaque désignées graphiquement d'une façon différente. La loi de répartition n'apparaît pas d'une manière bien frappante. La teneur en ammoniaque semble être plus élevée près des côtes qu'au large, dans les fonds peu profonds que dans les fonds profonds, mais en tous cas la distribution présente de notables anomalies ainsi qu'on le voit sur les stations 872 et 878, situées très près l'une de l'autre, dans le détroit compris entre Pico et São Jorge, et qui possèdent l'une une teneur très forte (152 milligrammes par kilogramme) et l'autre une teneur très faible (4 milligrammes). Un autre exemple est donné par les stations 1324 (89 milligrammes) et 1321 (46 milligrammes).

CARTE BATHYMÉTRIQUE GÉNÉRALE DES OCÉANS

Par J. THOULET, Nancy, France

Le Septième Congrès international de géographie, qui s'est tenu à Berlin en 1899, avait nommé une commission chargée de s'entendre au sujet de la confection d'une carte générale du relief subocéanique, de la terminologie des divers accidents du sol immergé et enfin du choix des noms destinés à les désigner. La commission se composait de MM. le baron de Richtofen, Son Altesse Sérène le prince de Monaco, le professeur O. Krümmel, l'amiral Makarow, Hugh Robert Mill, Sir John Murray, Fridtjof Nansen, le professeur O. Pettersson, le professeur Supan, et le professeur Thoulet.

Cette commission s'est réunie à Wiesbaden les 15 et 16 avril 1903, sous la présidence de Son Altesse Sérène le prince de Monaco. En outre de celui-ci, étaient présents: MM. les professeurs Krümmel, Hugh Robert Mill, O. Pettersson, Supan et Thoulet. Les autres membres s'étaient excusés.

M. Thoulet a donné lecture et discuté les conclusions d'un mémoire qu'il avait rédigé sur la question. Ses conclusions ont été adoptées.

Une carte générale des profondeurs océaniques sera faite à l'échelle de un dix-millionième (1: 10,000,000); elle comprendra 16 feuilles en projection de Mercator et 8 feuilles polaires en projection gnomonique sur deux plans parallèles aux plans tangents respectivement au pôle nord et au pôle sud et passant par les points de rencontre de la droite menée du centre de la sphère à 72° de latitude nord et sud avec le cylindre de projection non encore développé. Le méridien origine sera celui de Greenwich. Les isobathes tracées seront celles de 200, 500, 1,000, 2,000 . . . . mètres; les aires isobathes seron t teintées uniformément en bleu d'autant pus intense que la profondeur sera plus considérable. Les agrandissements régionaux de cette carte, s'il doit en être faits, seront exécutés autant que possible suivant des échelles multiples décimaux du dix-millionième. Un numérotage spécial permettra de désigner chaque feuille, soit de la carte type au 1 10,000,000^{e}, soit des feuilles à une échelle différente qui en seront dérivées et laissera reconnaître à quelle feuille type se rapporte la région particulière représentée dans des dimensions plus grandes.

Le prince de Monaco a déclaré qu'il se chargeait de faire dresser cette carte et que l'on s'efforcerait de l'avoir, sinon terminée, du moins aussi avancée que possible pour le prochain Congrès international de géographie, qui doit avoir lieu à Washington en 1904.

La commission a exprimé au prince ses remerciements les plus chaleureux pour sa généreuse initiative.

Au sujet de la terminologie des divers accidents du sol sous-marin, il a été décidé que les membres allemands s'entendraient entre eux sur une série très restreinte comprenant environ une quinzaine de noms, des termes les plus importants désignant ces accidents. Ces désignations seraient données en langue allemande accompagnés chacune d'une définition précise et succincte et l'usage en deviendrait dès lors obligatoire en Allemagne. La liste serait ensuite communiquée aux diverses nations qui établieraient en regard de chaque terme allemand le terme anglais ou français qui serait désormais considéré comme en étant l'exact et rigoureux synonyme. Ces termes seraient obligatoires pour l'ensemble des nations.

Les principaux accidents du sol sous-marin seront dénommés ainsi qu'ils l'ont été sur la petite carte des profondeurs océaniques dressée et publiée par le docteur Supan dans le volume de 1899 des Petermann's Geographische Mitteilungen. Mais ces désignations, en petit nombre d'ailleurs, étant adoptées, les accidents d'ordre plus secondaire seront nommés par leur découvreur, qui jouira à cet égard de la liberté la plus absolue.

Il reste entendu que dans le cas d'une double désignation, celle donnée par le premier decouvreur devra toujours être rétablie du moment où il sera prouvé qu'il est en réalité le premier découvreur. Le droit d'antériorité cet complet.

Ne sera considéré comme découvreur d'un accident topographique du relief sous-marin que celui qui en aura fixé la position au moins par trois sondages non en ligne droite et espacés les uns des autres de moins de 1 degré d'arc de grand cercle.

Conformément à la décision de la commission, le docteur Supan a publié dans les Petermann's Geographische Mitteilungen, 1903, Heft VII, les définitions adoptées en Allemagne pour les accidents du relief suboċéanique et la synonymie des termes allemands en anglais, établie par M. Hugh Robert Mill et en français par le professeur Thoulet. Cette dernière peut se résumer de la façon suivante:

I. FORMES DE PREMIÈRE GRANDEUR

1. Formes continentales:
   Socle ou plateau continental (Schelf, Shelf).
2. Formes profondes creuses:
   - (*a*) Bassin (Becken, Basin) et golfes (Buchten, Embayment).
   - (*b*) Vallée (Mulden, Trough) et Chenaux (Rinnen, Gully).
   - (*c*) Ravin (Gräben, Trench).

3. Formes profondes en relief:
   (*a*) Seuil (Schwellen, Rise).
   (*b*) Crête (Rücken, Ridge).
   (*c*) Plateau (Plateau, Plateau).
4. Fosse (Tiefen, Deep).
   Haut (Höhen, Height).

II. FORMES DE SECONDE GRANDEUR

1. Elévations:
   (*a*) Crête (Rücken, Ridge).
   (*b*) *α*. Dôme (Kuppen, Dome).
   β. Bancs (Bänke, Bank).
   γ. Récif (Riffe, Reef) ou Hauts-fonds (Gründe, Shoal).
2. Creux:
   (*a*) Caldeira (Kessel, Caldron).
   (*b*) Sillon (Furchen, Furrow).

Au Congrès de Washington M. Thoulet, après avoir donné lecture de l'historique précédent de la confection de la carte générale bathymétrique des océans, a prononcé les paroles suivantes:

Aussitôt après la conférence de Wiesbaden, le prince de Monaco se mit à l'œuvre; Monsieur l'enseigne de vaisseau *Sauerwein*, son officier d'ordonnance prit la direction du travail. Un appel aux Bureaux hydrographiques des diverses nations maritimes a tout d'abord permis de rassembler un nombre énorme de documents originaux qui ont été dépouillés et discutés un à un, chaque sondage indiqué a été reporté directement sur chacune des 24 feuilles de la carte par huit dessinateurs cartographes. Les cartes déjà publiées ont le plus souvent été écartées parce qu'il n'aurait pas toujours été possible de contrôler toutes leurs indications. Le travail est donc véritablement de première main. Pour chaque région particulière, note a été prise des documents employés de telle sorte que si une discussion s'élevait, rien ne serait plus facile que de justifier la forme représentée, d'indiquer les données qui l'établissent et le nom de celui qui les ayant récoltées sur le terrain, en garde dès lors l'entière responsabilité.

L'œuvre est achevée. Au nom de Son Altesse Sérène le prince Albert I de Monaco, j'ai l'honneur et, j'ose le dire, la fierté de la mettre sous les yeux du congrès. Voilà tout ce qui est aujourd'hui connu relativement au relief du lit océanique. Pendant de nombreuses années encore, marins, télégraphistes, ingénieurs, océanographes, savants vont continuer leurs sondages, car c'est par le détail qu'il faut maintenant procéder; aucun point d'aucune mer du globe n'échappera aux investigations. Le labeur incessant, infatigable des générations qui se succèdent est la gloire de l'humanité. Dans un siècle, dans dix siècles, voilà la carte que posséderont nos arrière—arrière-neveux, perfectionnée mais non changée.

Au nom de Son Altesse Sérène le prince Albert de Monaco, je demande pour ce travail l'approbation du congrès.

LISTE DES DOCUMENTS UTILISÉS POUR L'ÉTABLISSEMENT DE LA CARTE GÉNÉRALE BATHYMÉTRIQUE DES OCÉANS

[Echelle au 1 : 10,000,000.]

HÉMISPHÈRE NORD.

FEUILLE A I.

Cartes anglaises Nos. 2060 A (VII 02), 2060 B (VII 02), 786 (II 03).

Carte bathymétrique des Açores (1903).

Sondages exécutés par les navires dont les noms suivent: *Buccaneer* (1902), *Dacia* (1901, 1902, 1903), *Faraday* (1903), *François Arago* (1904), *Goldfinch* (1902, 1903), *John Pender* (1904), *Minia* (1901, 1903), *Mirador* (1903), *Newington* (1902, 1903), *Hirondelle* et *Princesse-Alice* (—— à 1903), *Amber* (1904), *Podbielski* (1902), *Valdivia* (1898, 1899).

FEUILLE A II.

Cartes anglaises Nos. 782 (VIII 01), 786 (II 03), 787 (II 03), 2060 B (VII 02), 2460 (X 00).

Sondages exécutés par le vapeur *Silverton*, sans date (List of oceanic depths, etc., 1903. Hydrographic Department, Admiralty, London, 1904, p. 12.)

FEUILLE A III.

Cartes anglaises Nos. 748 B (VI 02), 781 (XII 02), 1263 (IX 03), 2459 (XII 02).

Sondages des vapeurs *Investigator* (1902, 1903), *Dart* (1902), *Waterwitch* (1901).

FEUILLE A IV.

Cartes anglaises Nos. 449 (IV 03), 748 B (VI 02), 2202 A (XI 97).

Cartes russes des mers Caspienne et d'Aral.

Carte française de la mer Noire.

Sondages des vapeurs *Goldfinch* (1902, 1903), *Investigator* (1901, 1902, 1903), *Patrick Stewart* (1902), *Electra* (1903), *Princesse-Alice, Pola, Valdivia.*

FEUILLE B I.

Cartes anglaises Nos 2060 A (VII 02), 2060 B (I 03), 2177 (May, 1892), 2282 (May, 1903).

Sondages des vapeurs *Minia* (1903), *Faraday* (1903).

FEUILLE B II.

Cartes anglaises Nos. 787 (II 03), 2060 B (I 03), 2172 (X 00), 2443 (Oct., 81), 2460 (X 00).

FEUILLE B III.

Cartes anglaises Nos. 278 (Feb., 1899), 2388 (VII 99), 2443 (Oct., 81), 2459 (XII 02), 2460 (X 00).

FEUILLE B IV.

Cartes anglaises Nos. 2282 (May, 03), 2962 (VI 02), 2963 (Apr., 02).

Carte française No. 1464 (X 96).

FEUILLE C I.

Cartes anglaises Nos. 274 (May, 99), 2118 (I 83), 2177 (May, 1892), 2282 (May, 03), 2443 (Oct. 81).

Peary, Exploration polaire arctique (The Geographical Journal, décembre 1902).

Quatre années dans les glaces du Pôle, par Otto Sverdrup; traduction de Charles Rabot; cartes originales d'Otto Sverdrup (1904).

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Cartes anglaises Nos. 278 (Feb. 99), 2118 (I 83), 2172 (X 00).
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FEUILLE C III.

Carte anglaise No. 278 (Feb., 1899).

FEUILLE C IV.

Cartes anglaises Nos. 2282 (May, 03), 2962 (VI 02), 2751 (Aug., 01), 274.
Nota.—Les points extrêmes atteints par les diverses expéditions polaires arctiques ont été pris sur les cartes et ouvrages:
North polar regions, par J. G. Bartholomew, F. R. S. E.
Les grands itinéraires arctiques (insérée à la fin de l'ouvrage intitulé, La Conquête du Pôle, par Charles Bénard).
North polar explorations, par Commander R. E. Peary, U. S. N. (The Geographical Journal, 1903).
Quatre années dans les glaces du Pôle, par Otto Sverdrup; traduit par Charles Rabot.

HÉMISPHÈRE SUD.

FEUILLE A′ I.

Cartes anglaises Nos. 2202 A (XI 97), 2202 B (IV 03), 786 (II 03), 789 (IV 00).
List of Oceanic Depths, etc., 1903. Admiralty, London, 1904.
Sondage du vapeur *Dacia* (1902).
Deutsche Südpolar-Expedition, *Gauss*. Berlin, 1902, 1903.

FEUILLE A′ II.

Cartes anglaises Nos. 780 (XII 02), 783 (VI 02), 786 (VIII 02), 788 (VI 02), 789 (IV 00).
Notice to Mariners No. 2/87, Washington, 1903.
Notice to Mariners No. 434, Londres, 1903.
Notice to Mariners No. 22/125, Washington, 1903.
Avis aux Navigateurs Nos. 188, 189, Paris, 1903.
Sondages du vapeur *Penguin* (1903).

FEUILLE A′ III.

Cartes anglaises Nos. 2759 A (VIII 00), 2759 B (XII 01), 780 (XII 02), 748 A (XI 00), 748 B (VI 02), 1263 (IX 03), 788 (VI 02).
Sondages des vapeurs *Dart* (1902), *Penguin* (1902, 1903).
Notices to Mariners. Londres, 1903, No. 302; Washington, 1903, 2147.
Avis aux navigateurs.

FEUILLE A′ IV.

Cartes anglaises Nos. 748 A (XI 00), 748 B (VI 02), 2202 A (II 97), 2936 (XI 01), 2937 (XI 01).
Deutsche Südpolar-Expedition, *Gauss*. Berlin, 1902, 1903.

FEUILLE B′ I.

Cartes anglaises Nos. 2202 B (I 03), 786 (II 03), 1238 (Mar., 01), 3175 (June, 01), 3176 (June, 01), 1240 (III 01), 2483 (I 01).

Carte du commandant de Gerlache (*Belgica*), 1902.

Sondes de la *Scotia* (1903).

Deutsche Südpolar-Expedition, *Gauss*. Berlin, 1902, 1903.

FEUILLE B′ II.

Cartes anglaises Nos. 788 (I 03), 789 (IV 00), 3175 (June, 01), 3174 (June, 01), 3206 (June, 01), 3173 (June, 01), 1240 (III 01), 2683 (VI 02).

FEUILLE B′ III.

Cartes anglaises Nos. 788 (I 03), 2683 (VI 02), 1240 (III 01), 3206 (June, 01), 2937 (XI 01),-So.

Deutsche Südpolar-Expedition, *Gauss*. Berlin, 1902, 1903.

Sondages de la *Discovery* (national antarctic exploring ship) [1901].

FEUILLE B′ IV.

Cartes anglaises Nos. 2202 A (II 97), 748 A (XI 00), 1240 (III 01), 2937 (XI 01), 3170 (June 01), 3171 (June 01).

Deutsche Südpolar-Expedition, *Gauss*. Berlin, 1902, 1903.

FEUILLE C′ I.

Néant.

FEUILLE C′ II.

Carte anglaise No. 1240 (III 01).

FEUILLE C′ III.

Cartes anglaises Nos. 3177 (June 01), 1240 (III 01).

FEUILLE C′ IV.

Néant.

La terminologie des principales formes du relief sous-marin a été prise sur un planisphère inséré dans un mémoire du professeur Supan, publié dans les Petermanns Mitteilungen (49, 1903, VII), et dont la traduction, par M. Charles Sauerwein, a paru dans la Géographie, du 15 décembre 1903.

Nota.—Les points extrêmes atteints par les diverses expéditions polaires antarctiques ont été pris sur les cartes suivantes:

Expédition anglaise de la *Discovery* au pôle sud (1902).

Chart of the south polar regions, to accompany paper by W. S. Bruce.

Scottish national antarctic expedition. Map showing the track of the *Scotia*, 1903.

Sketch map showing the first year's work of the national antarctic expedition, to illustrate the paper by Sir Clements Markham, K. C. B. (The Geographical Journal, 1903).

Les cotes d'altitude ont été empruntées aux cartes anglaises, à l'Atlas universel de Vivien Saint-Martin et à l'Atlas Moderne de Schrader.

DESTRUCTION OF POMPEII AS INTERPRETED BY THE VOLCANIC ERUPTIONS OF MARTINIQUE

By Prof. ANGELO HEILPRIN, Philadelphia, Pa.

[Abstract.]

The eruptions of Pelée throw new light upon the first recorded eruption of Vesuvius, and render intelligible those passages in the narrative of Pliny which have heretofore been obscure and thought to be opposed by the facts of geology. The "horrible black cloud," scintillating with serpent-flashes of lightning, which is described as rolling down the mountain slope and blotting out the landscape, is seemingly the absolute counterpart of the great descending black cloud, similarly charged with electricity, which was the distinctive feature of the Pelée eruption of May 8, 1902. It was manifestly with the issuance of this cloud that Pompeii was destroyed, which was, therefore, on August 25 (not 24, as generally stated by historians), A. D. 79, as Pliny's narration makes clear that this climax of activity was reached on the second day of the eruption of Vesuvius. The speaker expressed his conviction that Pompeii was not destroyed as the result of simple incineration, as is generally assumed by geologists and others, but in a manner in all probability closely similar to that which annihilated St. Pierre. The numerous deformed objects of porcelain, glass, etc., which, as recovered from Pompeii, were thought to represent deformation effected during a long period of time, have again their exact counterpart in objects recovered from St. Pierre, where the deformation was accomplished in minutes or seconds.

TOWER OF PELÉE

By Prof. ANGELO HEILPRIN, Philadelphia, Pa.

[Abstract.]

The speaker detailed the general features of this remarkable structure, supplementing his observations with photographic views taken by him on June 13, 1903, from the crater rim. At that time the giant obelisk rose out from the new crateral summit (the "cone" or "dome") to a height of about 840 feet. The speaker dissented from the generally accepted view that this tower represented a rapidly cooling lava, whose solidification was effected at the time of extrusion, and expressed his belief that in all probability it was an ancient volcanic core, which had been dislodged and lifted out as the result of Pelée's forceful activity. Many facts connected with the structure of the tower, as well as its general cork-like aspect, supported this conclusion.

VOLCANOES OF MARTINIQUE, GUADELOUPE, AND SABA[a]

By EDMUND OTIS HOVEY, New York City

Since the time of their discovery by Christopher Columbus on his second and fourth voyages in 1493 and 1502, the Caribbean islands have been known to contain volcanoes. Few eruptions of note have occurred during this period of four centuries, but slight outbursts have been sufficiently numerous to maintain interest in the volcanic activity of the group.

For the purposes of the present discussion the volcanoes of the islands may be divided into two groups—those whose eruptions have been like the recent outbreaks of Mont Pelée, and those whose eruptions have been like the outbreaks of the Soufrière of St. Vincent. In the first group may be placed Mont Pelée of Martinique, the Grande Soufrière of Guadeloupe, and Saba; in the second group, the Soufrière of St. Vincent, Mount Misery of St. Kitts, and Statia. Grenada probably belongs in the second group, while Montserrat and Nevis belong in the first, but data are not yet at hand for definite classification. The characteristics of the first, or Pelée group, are eruptions of the massive, solid kind, which leave no true crater, and produce typical "bread crust" bombs of more or less pumiceous character from andesite of relatively high silica content. The second, or St. Vincent group, have true craters from which has come no solid extrusion similar to that which has made the present activity of Mont Pelée so remarkable. The volcanoes of Montserrat and Nevis are classed provisionally with the Mont Pelée type because they seem to have very much the same shape as that of Mont Pelée before the eruptions of 1902 began; that is, each presents a great crater whose wall is breached on one side to the base by a cleft which continues into a gorge of erosion.

The volcanoes of the Caribbean date from early Tertiary time and seem to be mountains of accumulation. Evidences of elevation are seen in the Tertiary limestone beds of Martinique, Guadeloupe, and other islands, while comparatively recent uplift is shown by the elevated sea beaches and benches of St. Vincent, Martinique, and other

[a] The data upon which this paper is based were obtained on two expeditions sent out by the American Museum of Natural History, New York, May 14 to July 15, 1902, and February 5 to May 8, 1903.

islands. Some observers, however, chief among whom is Dr. J. W. Spencer, contend that the chain of islands is a submerged mountain range, once continuous with the South American continent.

Martinique lies almost in the middle of the Caribbees, with the summit of Mont Pelée in latitude 14° 49′ north, and longitude 61° 10′ west of Greenwich. The island is of very irregular shape, is about 72 kilometers in length, is from 16 to 24 kilometers in width, and has an area of about 975 square kilometers. It is the second largest of the Lesser Antillean group, being exceeded in size by Guadeloupe alone. Before the year 1902 Mont Pelée was one of the higher mountains of the Caribbean islands, its accepted altitude being 1,350 meters above the sea. The volcano is situated, in relation to the rest of Martinique, as the Soufrière is to St. Vincent. At its base there are two great transverse valleys—that of the Roxelane River on the west and that of the Capot River on the east—corresponding to the gorges of the Wallibou and of the Rabaka at the base of the Soufrière. Mont Pelée consists for the most part of tuff agglomerate which has resulted from the weak consolidation of débris which has been thrown out in ancient explosive eruptions. There are some lava beds in the mountain, certain of which, like the "Coffin" near the Rivière Blanche, are flows, while some in the upper part of the old cone may have been plugs or the remains of spines. Deep gorges proceed in all directions from the summit of the mountain. Most of these are largely or wholly valleys of erosion; but one, the gorge of the Rivière Blanche, may have resulted in part from the action of volcanic forces. It appears to have begun as a rent torn in the rim of the crater by one or more explosive eruptions. The old crater is surrounded on the north by an old "somma ring."

The general history of the recent eruptions of Mont Pelée is too well known to require extended mention. Early in the year 1901 new fumaroles were observed within the crater of the volcano and the old steam vents there increased in activity during the su[illegible]eding months, but without exciting any alarm in the minds of th[illegible]itants of the island. For several weeks during March and A[illegible], there were suspicious rumblings in the mountain and th[illegible]ge of vapor became copious and even violent. During [illegible] part of A[illegible] dust and lapilli were thrown far and wide ov[illegible]es of the m[illegible] tain and frequently the sulphurous fumes [illegible] from the [illegible] were so strong in St. Pierre and along [illegible] to the [illegible] parts of the island that horses and m[illegible] as to their breathing. On May 5 [illegible] known as l'Étang Sec, within the c[illegible] formed by the newly ejected ma[illegible] lanche of hot mud the Guérin[illegible] the seashore at the mouth of [illegible]

from the crater. The preceding day stones the size of a pigeon's egg had been thrown as far as Macouba, 6 kilometers north of the crater.

The first great eruption of the present series took place at about 8 o'clock on the morning of May 8. This destroyed the city of St. Pierre and every living thing within it, with the possible exception of one or two men. This first eruption was characterized by the suddenness and magnitude of the explosion which overwhelmed the city and the immense quantity of impalpable dust which loaded the exploding steam to such an extent that the portion of the cloud issuing from the vent of the volcano possessed some of the properties of a highly mobile fluid. This fluid, propelled by a part of the force of the explosion, had such an initial velocity that it traversed the 8 kilometers between the crater and the middle of the city in less than three minutes. (Some observers of the eruption even cut this time down to one hundred seconds.) Except for comparatively small quantities of sulphur and perhaps other gases, the cloud seems to have been composed entirely of steam saturated with dust. The temperature of this cloud must have been very high, since it contained a vast quantity of incandescent solid matter. The force of the first explosion was concentrated toward the south and southwest by the configuration of the crater and the mountain. Walls 350 to 600 meters in height formed all sides of the crateral pit except the southwest, where a great V-shaped breach cleft them to the bottom. For this reason when the confined volcanic steam and other gases reached the top of the conduit in the bottom of the crater, they were free to expand horizontally only toward the southwest.

A cone began to form within the crater at once; indeed, such a feature had been observed by visitors to the crater a few days before the first great outburst occurred and had been described as a "cinder" cone. When the author first saw the mountain on May 21, 1902, the new cone, as observed from the deck of the United States tug *Potomac*, seemed to be 150 to 180 meters in height. Its growth was rapid, and by May 31 the top was about on a level with the eastern rim of the great crater. In the latter part of June, the height was about the same. At these times great masses of rock were observed projecting from the sides of the new cone, and early in July a mass like a shark's fin projected above the top of the cone. In August observers noted an obelisk above the top of the new cone which by this time rose many meters above the old summit of the mountain. All the observers who had noted these facts had failed to grasp the idea that the cone was anything different from the ordinary fragmental cone of an explosive volcano, and it was reserved for Professor Lacroix, the head of the French governmental scientific commission, to get observations in the middle of October which led him to the conviction that Mont Pelée is

a volcano of the cumulo-volcano type—namely, that the main body of the cone and the surmounting spine or tooth were pushed up bodily from below in a solid or practically solid condition. The present author holds to the theory that the new cone and spine were formed of fresh lava, which was too nearly solid to flow and that it was not the old plug pushed out.

From October, 1902, began the growth of the wonderful spine, which is the most striking feature of the eruption of any volcano within human history. The remarkable average of 12.5 meters a day was the record of upward growth for this portion of the mountain in eighteen days of November, 1902. On the 26th of that month the apex of the spine was 1,533 meters above the sea, or 183 meters higher than the old culminating point of the mountain, and 800 meters higher than the level of l'Étang Sec, the starting point of the new cone. In the succeeding five weeks about 103 meters of this altitude was lost, but in March, 1903, the spine began to rise again, and finally attained an altitude of 1,617 meters above the sea about the 1st of April (Lacroix).

The usual activity of the volcano seems to have pushed this cone and spine upward, while the eruptions which took place from time to time tended toward the destruction of the spine and the disintegration of the cone. During April, 1903, some of the spine was destroyed. In May the loss was recovered, but on May 30 about 50 meters was lost from the top. During June much of the old altitude was regained, but between July 5 and August 6 more than three-fourths of that part of the spine projecting above the new cone disappeared, and Mont Pelée's wonderful spine ceased to be a feature of the mountain. The loss of the spine, however, was made good in part by the elevation of the "dome," or main portion of the cone, which, by the middle of October, was about 121 meters higher than it had been before the loss of the spine. Since then the continued explosions in its mass have carried away the western portion of the top of the cone, leaving a sharp, almost overhanging, fin-like ridge along the eastern side of the cone. The outline, however, is changing constantly.

The axis of the new cone is not central within the old crater, but rises in the northwest quarter. There was a spiral valley between the new cone and the old crater, which gradually diminished in depth and disappeared on the western and northwestern sides, where, by March, 1903, the slope of the new inner cone had become continuous with that of the old outer cone. In June, 1902, the author estimated this valley to be about 240 to 250 meters deep beside the remains of Morne Lacroix on the eastern side of the crater. In March, 1903, he estimated that the valley at the same place could not have been more than about 60 meters deep, and the activity since that time must have gradually reduced even this depth. Judging from the débris found

in the valley of the Rivière Blanche and on the rim of the crater, the material of this new cone and spine is andesite, which is partly lithoidal, partly densely vitreous, and partly pumiceous in texture. The formation of true pumice during the present series of eruptions is indicated by the freshness of the material of this character which occurs scattered in loose blocks on many parts of the mountain.

The total destruction of the dense coating of tropical vegetation upon Mont Pelée has given an opportunity for studying the actual topography of the Caribbean volcanoes which has not been offered before for a century, and the thousands of photographs which have been taken on Martinique and St. Vincent since the eruptions began two years ago give valuable data for the study of the old topography of the islands, the effects produced by the blanket of ash deposited upon them and the subsequent erosion in the old and the new surfaces.

The Grande Soufrière of Guadeloupe is the loftiest mountain of the Caribbean islands, rising to a height of 1,484 meters above sea level. The earliest explorers report the issuance of steam from its summit, and in September, 1796, it suffered a slight eruption which deposited dust and lapilli over an area 10 to 15 square kilometers west and northwest of the peak. The mountain shows no definite crater, but the summit cone is cleft by two sets of great fissures which intersect each other at an oblique angle so as to form a gigantic letter X. The discharge of vapors from different parts of these fissures varies from time to time. For the last five years the activity has been upon the increase, not only in the Grand Soufrière itself but also in the Morne l'Échelle immediately adjoining on the southeast. The position of the present summit cone and its relations to its surroundings indicate that it has risen within an old conduit. This conduit may have terminated in a true crater such as existed at Pelée before May, 1902, which the present cone has filled and obliterated with the exception of a small area to the north and northwest which seems to be a part of an old crater rim. The cone consists for the most part of solid rock, and the indications are that this was extruded in a too nearly solid condition to flow and that, as at Pelée, the expansion which resulted on its release of pressure at the surface rendered it rigid. Pumiceous "bread-crust" bombs, similar to those of Mont Pelée, were observed on the slopes of Morne l'Échelle, where they probably had fallen from an eruption of the Soufrière.

Saba is an island which seems likewise to lack a true crater. Its summits are formed of solid lava, which is andesite containing a relatively high percentage of silica. "Bread-crust" bombs of the Pelée type are abundant. Although there are three or four depressions between peaks there does not seem to be any true crater upon the island and it is referred provisionally to the Pelée type of volcano.

VOLCANOES OF ST. VINCENT, ST. KITTS, AND STATIA[a]

By EDMUND OTIS HOVEY, New York City

The island of St. Vincent is about 30 kilometers long from north to south, about 16 kilometers wide, and has an area of about 350 square kilometers. It is entirely volcanic in origin and the eruptive activity has progressed from south to north. The Soufrière is the only active volcano in the island and is the only mountain possessing a crater. Its summit is in latitude 13° 20′ north and longitude 61° 12′ west of Greenwich, and is about 165 kilometers nearly due south of the summit of Mont Pelée. The Soufrière possesses two craters, the great or "old" crater, utilized by the eruptions of 1718, 1902, and 1903, and the "new" crater, which is at the side of the old crater and is stated to have been formed during the eruption of the year 1812. Around these craters upon the north rises a wall like that of Monte Somma around Vesuvius, and this is all that remains of the rim of an enormous crater more ancient than the present craters.

The phenomena of the more recent series of eruptions may be briefly summarized as follows: Earthquakes rather more severe than usual occurred in the spring of 1901. In April, 1902, the steam began to rise through the lake occupying the great crater. Rumbling noises within the mountain were heard at intervals from December, 1901. Afterwards these increased in frequency and strength, frightening the inhabitants of the leeward (western) side of the mountain, and the activity of the crater so increased that by the 6th of May that portion of the island was deserted.

The first heavy eruption began after noon of May 6 and culminated at 2 p. m. May 7. Other heavy eruptions occurred May 18, September 3 to 4, October 15 to 16, 1902; and March 21 to 30, 1903. All were explosive in character and no stream of lava accompanied any of the outbursts. As at Mont Pelée, a great excess of water vapor characterized all the eruptions, and heavy dust-laden clouds of steam (dust

[a] The data upon which this paper is based were obtained on two expeditions sent out by the American Museum of Natural History, New York, May 14 to July 15, 1902, and February 5 to May 8, 1903.

flows) rolled down the sides of the volcano, propelled by the horizontal component of the explosive force of the cloud. The analogy between the exploding clouds of the Soufrière and Mont Pelée was more evident in the eruption of the Soufrière on May 7 than in the later outbursts, because the dust of that eruption was much finer than that ejected afterwards. The cloud expanded radially with approximately uniform violence, there being no great gash in the rim of the crater like that of the gorge of the Rivière Blanche at Mont Pelée to concentrate the volcanic blast in a given direction. The high Somma wall on the north checked somewhat the advance of the cloud in that direction.

The dust, sand, and lapilli thrown out by the eruptions collected in thick beds in the valleys descending more or less radially from the cone. This was especially the case in the gorge of the Rabaka Dry River on the east and that of the Wallibou Dry River on the west. The heat confined in the interior of these beds gave rise to interesting secondary or superficial eruptions on the accession of local waters to the interior. During the weeks immediately after the eruptions some of the secondary eruptions were violent. They continued with diminishing force and frequency at least until March, 1903.

The form of erosion due directly to the eruptions was that caused by the volcanic dust and sand driven by the tornadic volcanic blast. Its effects, in St. Vincent were seen particularly in the fantastic carving of tree roots and branches near the crater.

The eruptions completely denuded the slopes of the mountain of their vegetation, and upon the barren surface deposited a bed of fresh volcanic ash varying from a few centimeters to 30 meters or more in thickness. The succeding rains speedily developed dendritic systems of drainage in this coating, but for the most part old erosion channels were scoured out anew. The rapidity of the reestablishment of old drainage channels was particularly striking in the Rabaka and Wallibou gorges. Enormous quantities of ash were carried out to sea through these and other channels by the rains. On the eastern or windward side this material extended the coast line from a few meters to 50 or 60 meters for a distance of about 11 kilometers along the northern half of the island. On the western side of St. Vincent the land descends too rapidly for the deposition of this new material along the shore except at the mouths of some of the rivers, notably the Wallibou.

Along the leeward (western) side the immediate shore lost a strip of land in places 100 meters wide through landslides induced by the eruptions. This loss extended at intervals for 5.5 kilometers northward from the mouth of the Wallibou River.

The great crater of the Soufrière is an enormous open pit about 1.4 kilometers in diameter from east to west and rather less than 1.3 kilo-

meters from north to south. Directly after the eruptions of May, 1902, the surface of the little mud lake in the bottom of the crater was estimated by the author to be 730 meters below the highest point of the rim. The heavy eruptions of September and October, 1902, seemed to have deepened the crater, for the author estimated the depth of the crater in March, 1903, to the surface of the mud lake in the bottom at about 800 meters. The walls of the crater show several alternations of beds of lava with beds of tuff. At least five beds can be seen in the east wall, while in the Somma ring, north of the crater, eight beds of lava can be counted.

The lava of St. Vincent is a hypersthene andesite of higher specific gravity and lower silica content than that of Mont Pelée. The bombs which were thrown out during the recent eruptions show effects of strains due to cooling from a molten condition, but do not present the "bread crust" surface so well developed as do those of Mont Pelée.

Mount Misery, on St. Kitts (St. Christopher), and the volcano of Statia (St. Eustatius) have enormous open pot-like craters similar in shape and appearance to that of the Soufrière of St. Vincent. Their walls show a similar alternation of lava with beds of tuff. The crater of Mount Misery contains a lake in the rainy season, but that of Statia is dry at all times of the year and is covered with a heavy growth of forest. There is no solfataric area within the crater of Statia, but Mount Misery shows such an area, known locally as the "Soufrière," in the southeastern side of the crater from 10 to 30 meters above the level of the lake. Bombs have not been reported yet from Mount Misery, but the author found on Statia bombs like those thrown out during the recent eruptions of the Soufrière of St. Vincent.

RELATIONS DE LA FIGURE DU GLOBE AVEC LA DISTRIBUTION DES VOLCANS ET TREMBLEMENTS DE TERRE

Par le professeur G. LALLEMAND

INSTABILITÉ DE LA CROÛTE TERRESTRE

Pour beaucoup de savants, dire que le système solaire est stable et que la croûte terrestre est en état d'équilibre, c'est, en quelque sorte, énoncer deux vérités n'ayant pas besoin de démonstration.

Ne voyons-nous pas, en effet, chaque année, les astres revenir, dans le ciel, exactement à la place que leur assigne une théorie basée sur l'immuabilité des orbites? Les occultations d'étoiles, les éclipses de lune et de soleil ne se reproduisent-elles pas avec une rigueur mathématique, à l'heure même indiquée par le calcul?

Et d'autre part, les déterminations de la gravité, les mesures d'arcs de méridien, ou bien encore les résultats de nivellements de précision, effectués en un même lieu du globe à des époques différentes, n'attestent-ils pas, par leur absolue concordance, la parfaite stabilité de la croûte qui nous porte? La répartition des continents et des mers, la distribution des montagnes et des fleuves, demeurées les mêmes depuis que l'homme a une histoire, n'en seraient-elles pas, au besoin, une preuve suffisante?

La géologie nous enseigne, il est vrai, que cette répartition n'a pas toujours été ce qu'elle est aujourd'hui: à l'époque crétacée, par exemple, le lieu où nous sommes était le centre d'une mer. De la masse gazeuse ou du globe de feu des temps originels à la sphère bosselée d'aujourd'hui, la figure de la terre a passé par maints aspects différents; mais on se plaît généralement à croire que chacun de ces changements était le résultat d'une catastrophe soudaine comme le déluge universel dont parle la Bible, et qu'entre deux cataclysmes consécutifs, l'écorce terrestre—la lithosphère, comme disent les géologues—gardait un équilibre stable ou à très peu près.

Avec sa magistrale autorité, M. H. Poincaré a dit ce qu'il fallait penser de la stabilité du système solaire.[a] Elle est parfaitement illusoire; le système entier s'achemine lentement vers l'inéluctable repos final. Et si, par exemple, on a pu longtemps croire à la constance de

la durée du jour et de l'année, c'est que les quelques dizaines de siècles sur lesquelles portent les observations humaines ne sont qu'un instant inappréciable, comparées à l'énorme durée des périodes géologiques.

Je voudrais essayer de montrer que la stabilité de la croûte terrestre n'est pas moins chimérique.

TREMBLEMENTS DE TERRE ET VOLCANS

Les éruptions volcaniques et les tremblements de terre, deux phénomènes qui présentent entre eux les relations les plus étroites et qui se produisent fréquemment ensemble, m'aideront à faire cette démonstration.

En parlant de tremblements de terre, je ne pense pas seulement à ces violentes secousses qui, en un instant, détruisent des cités entières et fauchent des milliers d'existences; je ne vise pas non plus d'une manière exclusive ces brusques trépidations du sol dont on compte jusqu'à deux par jour dans la partie du globe habitée par des peuples civilisés, ce qui en suppose une cinquantaine au moins pour le globe entier; mais je songe surtout à ces vibrations internes que, seuls, des instruments d'une extrême sensibilité parviennent à déceler, qui agitent le sol d'une manière continuelle et qui sont aux véritables tremblements de terre ce que la brise légère est au cyclone qui renverse les murs et déracine les arbres, ou encore ce que la houle et le clapotis sur mer sont à la vague énorme qui chavire les bâtiments et emporte les jetées des ports.

Ces petits mouvements du sol, que les dépressions barométriques semblent amplifier, sont plus fréquents en hiver qu'en été, et augmentent ordinairement d'intensité à l'approche des équinoxes, où ils dégénèrent fréquemment en tremblements de terre, surtout dans la région intertropicale.

Ces divers phénomènes, désignés sous le nom générique de séismes, sont aujourd'hui l'objet d'études suivies dans des observatoires installés à cet effet chez la plupart des peuples civilisés, notamment en France, en Allemagne, en Italie et surtout au Japon, pays d'élection des tremblements de terre. Des sociétés séismologiques nationales et même une association internationale, analogue à l'Association géodésique, se sont créées en vue d'assurer, par l'uniformité des instruments et des méthodes, la coordination des résultats de cette nouvelle science, à laquelle les Italiens ont déjà donné le nom caractéristique de météorologie interne (*meteorologia endogena*), pour marquer sa parenté avec la météorologie atmosphérique. Il n'est peut-être pas chimérique d'espérer qu'un jour viendra où l'on pourra signaler d'avance les tremblements de terre comme on prédit aujourd'hui l'arrivée des tempêtes d'une rive à l'autre de l'Atlantique. Ainsi, contrairement à une opinion trop répandue, le sol sur lequel nous marchons est dans un perpétuel état de mouvement. Mais à quelle cause attribuer ce phénomène?

ORIGINE DES TREMBLEMENTS DE TERRE ET DES VOLCANS

Pour certains auteurs, admettant l'hypothèse de la fluidité du noyau central et de sa solidification lente sous l'effet du rayonnement dans l'espace, les soubresauts en question résulteraient de l'accumulation, sous la croûte terrestre, soit de gaz chassés du bain liquide par les progrès du refroidissement, soit de masses de vapeurs produites par l'infiltration des eaux de la mer dans les profondeurs du globe, jusqu'au contact des matières ignées.

D'autres, niant l'existence d'une masse en fusion au centre de la terre, attribuent ces commotions à des réactions chimiques de diverses natures, à des éboulements souterrains, ou même à des actions électriques.

Mais ce ne sont là que des explications en quelque sorte locales et immédiates; elles ne montrent pas la loi d'ensemble dont, pourtant, l'existence paraît certaine, si l'on refléchit au caractère quasi universel et simultané des phénomènes en question. On compte, à la surface de la terre, plus de trois cents cratères en activité et plus du double de volcans éteints ou du moins assoupis. Depuis près d'un an, nous assistons au réveil successif d'une quantité de ces foyers, répartis sur tous les points du globe: aux Antilles, dans l'Amérique centrale, au Chili, dans l'Alaska, l'océan Indien, le Pacifique, et même en Europe. Chaque jour le télégraphe apporte l'annonce de nouveaux tremblements de terre survenus soit au Japon, aux Philippines, dans l'Inde, au Turkestan, dans le golfe Persique ou le Caucase, soit en Australie, dans la chaîne des Cordillères ou au Guatémala. Des îles même disparaissent tout à coup dans la mer Jaune et dans le golfe du Mexique.

Cette recrudescence d'activité des forces internes du globe constitue, à n'en pas douter, un phénomène absolument général.

THEORIE TÉTRAÉDRIQUE DE LA FIGURE DE LA TERRE

Il y a une vingtaine d'années, à la suite d'un voyage de mission en Italie pour étudier l'organisation des observatoires séismographiques établis dans ce pays, j'eus l'impression que l'origine des tremblements de terre[a] se rattachait, de la manière la plus naturelle, à une ingénieuse théorie émanant d'un savant anglais, M. Green,[b] alors ministre des affaires étrangères des îles Sandwich, et qui avait été, chez nous, exposée avec une remarquable clarté, sous le nom de sytème tétraédrique, par l'éminent géologue M. de Lapparent.[c]

Voici en quoi consiste cette théorie, qui prétend expliquer la distribution actuelle des continents et des mers à la surface du globe et qui, dans ces dernières années, a été, pour deux maîtres géologues de l'Ins-

[a] **Lallemand, Ch.**, Note sur l'origine probable des tremblements de terre (Comptes rendus de l'Académie des sciences, séance du 22 mars 1886).

[b] **Green, W. L.**, Vestiges of the molten globe, Honolulu, 1875.

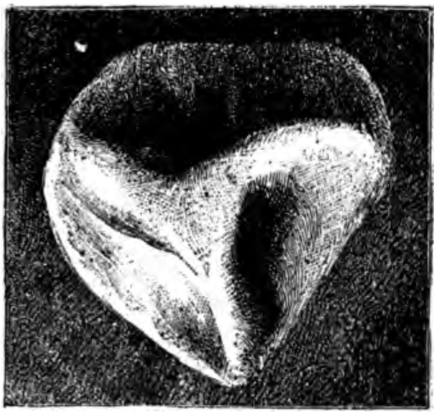
[c] **Lapparent, A. de**, La symétrie sur le globe terrestre (Revue des questions scientifiques, Bruxelles, 1882).

titut de France, MM. Michel Lévy et Marcel Bertrand, l'occasion de travaux et de mémoires du plus haut intérêt.[a]

Tout d'abord, M. Green adopte la vieille hypothèse du noyau central fluide, hors de laquelle ne sauraient guère s'expliquer les faits que j'ai rappelés et qui supposent l'existence de forces intérieures permanentes et universelles. C'est déjà sur cette même hypothèse qu'Élie de Beaumont avait édifié sa fameuse théorie des soulèvements de montagnes, connue sous le nom de théorie du réseau pentagonal.

Supportée par la masse centrale ignée, l'écorce terrestre en se refroidissant tendrait à prendre une forme générale dérivée de la pyramide à base triangulaire, plus simplement désignée sous le nom de tétraèdre.

M. Green avait été conduit à cette théorie par l'examen des résultats de Fairbairn, où des tuyaux de caoutchouc, comprimés extérieurement, avaient pris une section triangulaire à côtés concaves. Par analogie, M. Green en avait conclu que, dans des conditions semblables, une sphère creuse, soumise à une pression dirigée du dehors vers l'intérieur, devait prendre une forme tétraédrique.



Ballon de caoutchouc dans lequel on a fait un vide partiel.

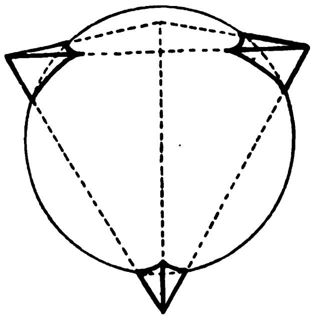
J'eus la curiosité de vérifier experimentalement cette dernière hypothèse en aspirant peu à peu l'air contenu dans un ballon de caoutchouc.[b] Il prit la forme représentée sur la figure. Plus tard, en Belgique, MM. Ghesquière et de Joly[c] ont obtenu la même confirmation pratique en faisant un vide partiel dans les ballons de verre ramollis par la chaleur.

Il m'avait d'ailleurs semblé qu'on pouvait donner de ce phénomène une explication théorique très simple. En vertu du principe de la moindre action, l'écorce terrestre, en effet, dans la déformation qu'elle subit pour rester en contact permanent avec le noyau central en voie de retrait, doit tendre, comme l'enveloppe du ballon de verre ou de caoutchouc, vers la forme qui lui impose le minimum de contraction superficielle, c'est-à-dire, vers la forme qui embrasse le plus petit volume sous une surface extérieure donnée. Or, cette forme est précisément celle du tétraèdre régulier.

[a] Comptes rendus de l'Académie des sciences, année 1900.
[b] Voir La Nature, No. 726, du 30 avril 1887, p. 346.
[c] R. de Girard, La théorie tétraédrique de la forme de la terre (Revue thomiste, 3e année, p. 497 à 741.

Cependant, le tétraèdre, avec ses quatre pointes saillantes, semble, à priori, loin de réaliser l'équivalent de la partie solide du globe terrestre, dont la figure générale est si voisine de celle d'une sphère.

Mais il ne faut pas oublier que, si la symétrie tétraédrique n'est pas plus immédiatement apparente, cela tient uniquement à ce que la géographie terrestre est le résultat de la combinaison de la pyramide avec son enveloppe maritime, constituée par une sphère légèrement aplatie, ayant pour centre le centre de gravité de la pyramide et renflée, comme on sait, parrallèlement à l'équateur, par l'effet de la rotation diurne. Les régions avoisinant les sommets doivent donc seules émerger au-dessus de la surface des eaux. Si, comme il est naturel, l'axe terrestre coïncide avec un des axes de symétrie du tétraèdre, il doit exister, dans l'un des deux hemisphères, trois saillies continentales, tandis que le pôle correspondant sera occupé par une mer et qu'une protubérance continentale se fera jour au pôle opposé. Or, il suffit de jeter les yeux sur un globe terrestre pour constater que ces conditions se trouvent pleinement réalisées.



Tétraèdre en partie enveloppé par une sphère concentrique.

On sait, en effet, que la terre ferme est, d'une manière remarquable, concentrée dans l'hémisphère boréal, où elle se répartit en trois massifs: le massif américain, le massif européen avec l'Afrique comme prolongement, le massif asiatique avec sa queue australienne. En outre, le pôle nord est recouvert par une mer profonde, dont l'existence est devenue hors de doute depuis que le docteur Nansen, dans sa dernière exploration polaire, y a trouvé des fonds de 3,800 mètres. Le pôle antarctique, au contraire, est le centre d'un continent, qui sert d'appui aux vastes banquises de l'hémisphère austral et dans lequel Ross a reconnu la présence de sommets très élevés, atteignant 4,000 mètres.

Entre les massifs continentaux, d'autre part, s'étendent trois nappes océaniques: le Pacifique, l'Atlantique et l'océan Indien.

Cette ordonnance, il est vrai, paraît un peu en défaut, puisque l'Asie et l'Europe ne présentent entre elles aucune solution de continuité. Mais ce désaccord s'atténue beaucoup si l'on veut bien se rappeler que toute la moitié occidentale de la Sibérie forme une contrée déprimée, qu'un très léger abaissement ramènerait au-dessous de l'océan. Cette dépression, qui longe le pied de l'Oural, est déjà du reste, nettement accusée par la présence de la mer Caspienne. La séparation des deux massifs devait fort probablement exister à une époque qui n'est pas encore très reculée.

Il est, en outre, aisé de voir, d'une part, que les massifs conti-

nentaux groupés autour des saillies doivent se terminer en pointe vers le sud et dans le sens de l'est à l'ouest et, d'autre part, que les nappes océaniques doivent diminuer constamment de largeur à mesure qu'elles arrivent dans des latitudes plus élevées.

C'est ce que la géographie confirme.

Est-il, en effet, rien de plus frappant que la forme aiguë que prennent, vers le sud, l'Amérique, l'Afrique et le continent australo-asiatique? Ne voit-on pas aussi l'Asie et l'Amérique russe tendre à se rejoindre à travers le détroit de Bering et diriger, l'une vers l'autre, deux pointes allongées?

Pour achever l'identification de la forme générale du globe avec le système tétraédrique, il me reste maintenant à dire un mot d'une particularité de la plus haute importance, que cette théorie semble laisser inexpliquée. Je veux parler de la grande dépression intercontinentale, sorte de ceinture maritime, qui partage le sphéroïde terrestre en deux moitiés. L'Europe est separée de l'Afrique par la Méditerranée; l'Asie de l'Australie par une série de mers plus ou moins fermées entourant les îles de l'archipel polynésien. L'Amérique du Nord n'est rattachée à l'Amérique du Sud que par l'isthme de Panama; les Antilles émergent à peine du fond qui relie les deux continents.

M. Green justifie l'existence de cette dépression en faisant intervenir le phénomène de la rotation diurne, jusqu'ici laissé de côté.

A l'origine, alors que la matière était encore plastique, le globe devait affecter la forme parfaitement sphérique. Mais au fur et à mesure des progrès du refroidissement, la forme tétraèdrique s'accentuant, les trois saillies de l'hémisphère nord s'éloignaient chaque jour davantage de l'axe de rotation, tandis que les parties voisines de la pointe australe s'en rapprochaient au contraire. Les protubérances septentrionales se trouvaient donc avoir une vitesse de rotation plus faible que les points correspondants de la sphère primitive et restaient, par conséquent, en retard dans le mouvement de rotation de la terre sur elle-même, pendant que les terres de l'hémisphère sud, conservant un excès de vitesse, prenaient de l'avance vers l'est.

De là, une sorte de torsion du solide tétraédrique, qui a fait naître, entre les reliefs septentrionaux et leurs prolongements vers le sud, une ligne de rupture, dont la suite de dépressions occupées aujourd'hui par la Méditerranée, le golfe Persique, les mers de la Sonde et le golfe du Mexique, atteste l'existence et jalonne le parcours.

Il faudrait aussi voir, dans ce phénomène, la raison pour laquelle les terres de l'hémisphère austral: Amérique du Sud, Afrique et Australie, sont toutes rejetées vers l'est par rapport aux continents septentrionaux dont elles forment les prolongements.

Telle est, dans ses traits principaux, la théorie tétraédrique. On lui a fait, il est vrai, cette objection que l'ensemble des mesures géodésiques concourt à assigner à la terre la figure d'un ellipsoïde et non

celle d'une pyramide. Cette contradiction n'est qu'apparente.[a] La géodésie ne définit-elle pas, en effet, la forme de la terre par la surface générale des mers prolongée par la pensée au-dessous des continents? Rien d'étonnant dès lors qu'elle trouve, comme résultat de ses mesures, la figure ellipsoïdale que la mécanique des fluides assigne à l'océan. La théorie tétraédrique, au contraire, faisant abstraction des eaux, vise exclusivement l'écorce solide, dont le relief, par rapport à l'ellipsoïde des mers, est affaire de nivellement, non de triangulation.

Et, d'autre part, ne serait-il pas facile de trouver, dans les anomalies constatées de la gravité sur les continents, des arguments à l'appui de la thèse en question?

Si, en effet, la surface extérieure de la lithosphère présente une figure ellipsoïdale avec une légère déformation tétraédrique, cette déformation, toutes choses égales d'ailleurs, doit se retrouver en petit dans les surfaces de niveau du globe et se traduire par des irrégularités correspondantes dans les mesures de la pesanteur réduite au niveau de la mer, c'est-à-dire diminuée de l'attraction de la masse solide émergeant au-dessus de l'océan. Par exemple, au voisinage des sommets du tétraèdre, la surface fondamentale de niveau (surface de niveau zéro, communément appelée la géoïde), faisant saillie sur l'ellipsoïde normal des géodésiens, l'attraction centripète doit y être plus faible et, en même temps, la composante verticale de la force centrifuge plus grande que sur l'ellipsoïde, double motif pour que la pesanteur effective, différence de ces deux actions, y soit moins forte que la pesanteur normale, calculée pour l'ellipsoïde, d'après la loi de Clairaut. Or, précisément, les mesures continentales de la gravité s'accordent toutes pour accuser un déficit de pesanteur dans les grands massifs montagneux, comme ceux des Alpes ou de l'Himalaya, par exemple.

M. Faye expliquait ces anomalies par l'existence de vides ou tout au moins de matières moins denses sous les continents. Sans nier l'influence de telles causes dans la production des irrégularités en question, on peut se demander si une partie au moins ne serait pas due à la déformation tétraédrique de l'écorce.

Un autre critérium de la déformation tétraédrique du géoïde serait fourni par la mesure de l'aplatissement du globe dans l'hémisphère sud. Par suite de la disposition et surtout de la moindre importance des saillies continentales dans cet hémisphère, l'aplatissement, en effet, devrait y être trouvé un peu moindre que celui résultant des mesures actuelles d'arcs de méridiens, dont la plupart ont été prises dans la partie moyenne de l'hémisphère nord. On peut espérer que, dans un avenir prochain, cette dernière confirmation nous sera fournie par la mesure, que projettent les Anglais, d'un arc de méridien allant du Cap au Caire, en Afrique, et aussi par celle, à laquelle songent les États-

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[a] Lallemand, Ch., La déformation tétraédrique de l'écorce terrestre et la pesanteur: La Nature No. 1250 du 15 mai 1897.

Unis, d'un arc analogue à travers l'Amérique du Sud, complétant et prolongeant l'arc de Quito, objet actuel des travaux de la mission française organisée, sous le contrôle de l'Académie des sciences, par le général Bassot et dirigée par le commandant Bourgeois.

RÉPARTITION DES VOLCANS ET DES TREMBLEMENTS DE TERRE À LA SURFACE DU GLOBE.

Il me reste à montrer le lien qui rattache à la théorie tétraédrique les phénomènes sismiques et les éruptions volcaniques.

La contraction résultant du refroidissement du noyau a dû avoir pour conséquences des plissements de l'écorce, au début, alors qu'elle était encore plastique, puis, plus tard, des fractures, lorsqu'elle est devenue plus résistante.

Le choc résultant de la rupture de l'équilibre en un point déterminerait des vibrations multiples, d'amplitudes comme de périodes différentes, se propageant dans toutes les directions et produisant leur maximum d'effet le long des surfaces préexistantes de dislocation. Les plus rapides de ces vibrations, qui sont en même temps les plus destructives, s'éteindraient très vite, en vertu de l'inertie de la matière, et ne feraient sentir leur action que dans une zone restreinte autour de leur foyer d'origine. Les oscillations lentes, au contraire, se propageraient très loin, avec des vitesses et des intensités variables suivant le degré de continuité et d'élasticité des couches terrestres.

Les manifestations du travail intérieur de l'écorce se traduiraient ainsi par des phénomènes vibratoires continus et, de temps à autre, par des crises plus violentes, c'est-à-dire par des tremblements de terre.

A travers les fissures ainsi produites dans l'enveloppe, dit M. de Lapparent, dans son beau Traité de géologie, la masse fluide interne se ferait jour et s'épancherait au dehors sous forme de lave. De temps en temps, les gaz emprisonnés atteindraient une tension suffisante pour provoquer de violentes explosions; d'autres fois, au contraire, comme aux îles Sandwich, les matières seraient assez fluides pour ne pas obstruer les cheminées; l'ascension de la lave serait alors continue et exempte de phénomènes explosifs.

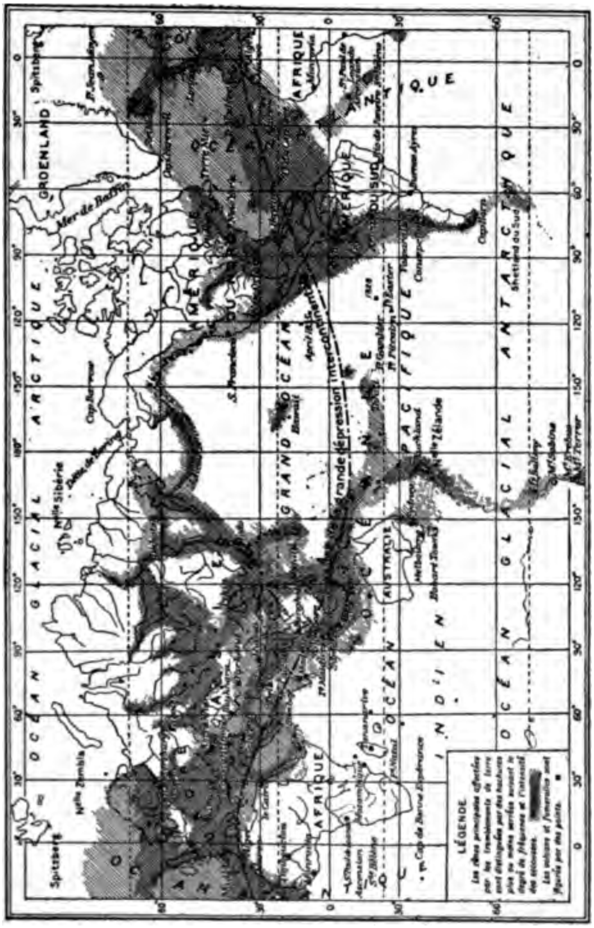
Pour M. Armand Gautier,[a] de l'Institut, les masses de gaz et de vapeur d'eau observées dans les éruptions volcaniques proviendraient des roches cristallines superficielles, réchauffées jusqu'au rouge par le contact de matières en fusion venant des profondeurs.

Les éruptions volcaniques et les tremblements de terre ne seraient ainsi que la conséquence naturelle et logique des mouvements de la lithosphère.

[a] Remarque sur l'origine des phénomènes volcaniques: Comptes rendus de l'Académie des sciences, du 5 janvier 1903.

Ces manifestations, bien entendu, se produiraient de préférence dans les régions où l'écorce a subi les plus grandes déformations et qui, par conséquent, sont restées des zones de moindre résistance, appelées à céder au premier effort.

Les lieux de prédilection des secousses seraient donc les régions avoisinant les arêtes et les sommets du tétraèdre et surtout la grande dépression intercontinentale, où la torsion de la pointe australe de la toupie terrestre ajoute ses effets à ceux du plissement des arêtes.



Carte de la répartition des tremblements de terre et des volcans à la surface du globe, montrant leur relation avec la figure tétraédrique et avec la grande dépression intercontinentale. Les zones principales affectées par les tremblements de terre sont distinguées par des hachures plus ou moins serrées, suivant le degré de fréquence et l'intensité des secousses. Les volcans et fumerolles sont figurés par des points.

L'existence d'une marée intérieure luni-solaire, en concordance avec les grandes marées de l'océan, pourrait enfin, au voisinage de l'équateur et dans toute la zone tropicale, devenir, à certains moments, la cause de la rupture de l'équilibre.

L'examen des faits confirme la réalité de ces inductions. Comme on le voit sur le planisphère ci-après, reproduction d'une carte[a] dressée

[a] Cette carte est incomplète, surtout en ce qui regarde l'Afrique, dont le centre était encore inconnu à l'époque où elle a été dressée.

par R. Mallet en 1858, l'Espagne, l'Italie, la Grèce, l'Algérie, autour de la Méditerranée; l'archipel des mers de la Sonde, l'Indo-Chine, dans le massif asiatique; l'Amérique centrale et les Antilles, tous pays situés le long de la grande dépression intercontinentale, sont, en effet, les terres classiques où les tremblements de terre et les éruptions volcaniques atteignent leur maximum de fréquence et d'intensité. Il en est de même, bien que peut-être à un degré moindre, de l'arête montagneuse du continent américain, ainsi que du Japon et des îles Aléoutiennes qui forment le trait d'union entre les massifs asiatique et américain.

En résumé, loin d'être inerte comme on le croit trop souvent, le sol que nous foulons est une matière vibrante—j'allais dire vivante. Tremblements de terre et volcans sont le *memento quia pulvis es*, le signal d'alarme qui nous rappelle incessamment la fragilité des choses terrestres et nous invite à contempler, dans la face verruqueuse et glacée de la lune, l'image de ce que sera, dans quelques millions d'années, notre globe désert, parvenu au stade final du refroidissement—et de la mort.

VERTIKALE BODENBEWEGUNGEN BEOBACHTET MIT DEM TRIFILARGRAVIMETER

Von A SCHMIDT, Stuttgart

Voriges Jahr, auf dem zweiten internationalen Seismologen-Congress zu Strassburg, hat der zum grossen Verluste der seismischen Forschung indessen in jungen Jahren verstorbene Italiener Cancani einen bemerkenswerten Vorschlag gemacht. Zur exacten Kennzeichnung der Stärke von Erdbebenstössen empfahl er, die Intensitätsscala von Rossi-Forel, beziehungsweise von **Forel-Mercalli** genauer zu definieren oder zu ersetzen durch eine Scala der Bodenbeschleunigungen, welche annähernd in geometrischer Progression sich abstuft in 12 Stufen von 2.5 bis 10,000 Millimeter. Es gibt ja Fälle von Erdbeben, z. B. dasjenige von Caracas vom Jahr 1811, wo die Pflastersteine aus dem Boden in die Höhe flogen, also die vertikale Beschleunigung den Wert von $g=9,810$ Millimeter überschritten hat.

Ohne das Für und Wider dieses Vorschlags näher zu erörtern—es bildet ja neben der Grösse der Beschleunigung auch deren Dauer einen die Wirkungsgrösse eines Stosses mitbestimmenden Factor—möchte ich hervorheben, dass die Bodenbeschleunigung geeignet ist, einen Massstab für die Empfindlichkeit der Seismometer zu liefern.

Die Leistung eines Seismometers ist den Functionen unserer Sinne vergleichbar. Die Physiologen bestimmen für die Sinnesorgane sogenannte Schwellenwerte, Minima der Stärke der Reize, auf welche unsere Sinne reagieren. Ein Seismometer ist umso empfindlicher, je niederer sein Schwellenwert liegt, d. h. je kleiner die Bodenbeschleunigung ist, auf welche das Seismometer reagiert. Die Einführung photographischer Registrierung durch Rebeur-Paschwitz, die Anwendung sehr grosser Massen bei der mechanischen Registrierung des astatischen Pendels von Wiechert sind wichtige Fortschritte in der Erniedrigung der Schwellenwerte. Einen ganz besondern Vorteil aber für die Erniedrigung der Schwellenwerte dürfte die Einführung eines neuen Princips der Seismometrie bieten.

Die verchiedenen Arten der gebraüchlichen Seismometer sind Annäherungen an eine ideale Construction, bei welcher dem bewegten

Erdboden eine der Bewegung entzogene Masse gegenübersteht, durch deren relative Verschiebung, mit beliebiger Hebelübersetzung, die Aufzeichnung der Bodenbewegung bewirkt wird. Pendelnd aufgehängte Massen von möglichst grosser Schwingungszeit nähern sich dem unerreichbaren Ideal am besten. Bei unendlich grosser Schwingungszeit würde die Schrift ein getreues Abbild derjenigen horizontalen oder vertikalen Componente der Bodenbewegung darstellen, für welche der Apparat gebaut ist. Am wenigsten ist es bis jetzt gelungen, die vertikale Componente getreu zu registrieren.

Es gibt nun ein zweites Princip der Seismometrie, welches ganz besondere Vorteile verspricht. Statt die Bodenbewegung selbst durch eine Curve $y = f(x)$ zu registrieren, wobei die Abscisse x der Zeit, die Ordinate y dem jeweiligen Abstande von der Gleichgewichtslage proportional ist, kann man auch eine Curve $y'' = \varphi(x)$ zu erhalten suchen, deren Ordinate $y'' = \frac{d^2y}{dx^2}$ der jeweiligen Beschleunigung der Bewegung proportional ist.

Man denke sich z. B. einen langsam hin- und hergeschobenen Eisenbahnwagen. Es wäre schwierig, die grossen Wege des Wagens mittelst eines im Innern des Wagens aufgestellten Horizontalpendels abzubilden. Würde man aber im Innern des Wagens ein kurzes Pendel mit sehr kleiner Schwingungszeit aufhängen, so würden dessen auf photographischem Wege leicht registrierbare Ausschläge ein getreues Abbild der jeweiligen Beschleunigung des Wagens darstellen. Nach Wunsch liesse sich aus der Curve $y'' = \varphi(x)$ die andere $y = f(x)$ herleiten, für die Erdbebenbeobachtung aber ist die unmittelbare Kenntniss von y'' mindestens ebenso wichtig, als diejenige von y. Das beweist Cancani's Vorshlag einer exacten Intensitätsscala. Im Fall reiner Sinusschwingungen von der Amplitude a und der Periode t ergibt die Gleichung $y = \pm a \sin \frac{2\pi x}{t}$ die andere $y'' = \mp \frac{4a\pi^2}{t^2} \sin \frac{2\pi x}{t}$, auch die Curve der Beschleunigungen ist eine Sinuscurve von derselben Periode und es ist $y = -y'' \frac{t^2}{4\pi^2}$.

Ich zweifle nicht, dass nach diesem Princip der Seismometrie die horizontalen Componenten der Bodenbewegungen mit Erfolg durch Pendel von einer halben oder einer drittel Secunde Schwingungszeit registriert werden könnten. Man hätte den Vorteil, durch keinerlei Dämpfungsvorrichtung die Empfindlichkeit beeinträchtigen zu müssen. Zunächst habe ich die Methode auf die Beobachtung der Vertikalcomponente angewendet. Mein Apparat ist das von mir mehrfach besprochene[a] Trifilargravimeter.

Obgleich es mir noch nicht gelungen ist, die Schwingungszeit des

[a] Gerland, Beiträge zur Geophysik, IV, 1899, p. 109; V, 1901, pp. 239 und 313; Ergänzungsband, 1902, p. 254.

Apparates unter den Betrag von 1.5 Secunden herabzusetzen und die Dämpfung ganz zu entbehren, so haben doch die bis jetzt unregelmässig angestellten Versuche, Dank der grossen Empfindlichkeit des Apparates, nicht uninteressante Beobachtungen geliefert. Deutliche Ausschläge bei Erschütterungen in der Nähe und bei schwachen Fernbeben wurden an meinem in Stuttgart aufgestellten Apparat und an dem gleichgebauten der kaiserlichen Hauptstation in Strassburg mehrfach wahrgenommen. Insbesondere aber sind es vertikale Pulsationen, welche ich in grosser Zahl, meist in combinierten Wellenformen zu beobachten Gelegenheit hatte. Unter den regelmässigen Sinuswellen erwähne ich als schönstes Beispiel diejenige vom 30. November 1903, von welcher kein anderes deutsches Seismometer eine Andeutung gab. Während 13 Stunden, an Höhe ab- und wieder zunehmend bildeten sich Wellen von 8–10 Minuten Periode und 1.2 Millimeter grösster Höhendifferenz zwischen Berg und Thal. Der Apparat war so eingestellt, dass eine Aenderung der Schwerebeschleunigung um 1:10,000 ihres Betrags einen Ausschlag von 50 Millimeter erzeugte. Die Beschleunigungen des Bodens erreichten daher keine höheren Beträge als etwa 1:800,000 der Schwerebeschleunigung. Trotz der ausserordentlichen Kleinheit dieses Wertes entsprechen ihr sehr grosse Werte der vertikalen Bodenbewegung, nähmlich nach der oben gegebenen Beziehung zwischen y und y'' Werte von 9 Centimeter über und unter der Gleichgewichtslage, also von 18 Centimeter Höhendifferenz. Annähernd so hohe Beträge berechnen sich aus den Aufzeichnungen anderer Tage. Wem es widerstrebt, so gewaltige wogende Bewegungen des Erdbodens in langsamer Periode anzuehmen, der muss sich auf unwahrscheinlichere Ursachen einer periodischen Zu- und Abnahme der Schwerebeschleunigung besinnen, etwa eine periodische Annäherung und Entfernung grosser Massen des flüssigen Magmas, aber auch eine solche Ursache müsste Oscillationen der Erdkruste mit erzeugen.

Nach der bald in Aussicht stehenden Aufstellung meines Apparates in der still gelegenen neu erbauten Seismometerstation Hohenheim bei Stuttgart hoffe ich, hier und in Strassburg werden wir fortlaufende Beobachtungen erhalten, welche einen weiteren Einblick in die vertikalen Bodenbewegungen gewähren.

GRÜNDUNG, ORGANISATION UND AUFGABEN DER INTERNATIONALEN SEISMOLOGISCHEN ASSOZIATION

Von Professor Dr. G. GERLAND, Direktor des Centralbureaus in Strassburg

Die erste Anregung zur Einrichtung einer alle Kulturstaaten umfassenden internationalen Erdbebenbeobachtung und der darauf begründeten systematisch betriebenen Erdbebenforschung ist von mir im Verein mit Dr. E. von Rebeur-Paschwitz ausgegangen. Die Veranlassung dazu hatten uns die günstigen Erfolge gegeben, welche letzterer mit dem von ihm verbesserten Horizontalpendel bei der Beobachtung von Fernerdbeben erzielt hatte. Mit den Vorschlägen zur Errichtung eines internationalen Systems von Erdbebenstationen, welche von Rebeur verfasst hat, wollten wir in erster Linie die Gründung eines über die ganze Erde verbreiteten Netzes von seismischen Stationen in Anregung bringen, auf denen mit Hülfe von hochempfindlichen Apparaten die Ausbreitung der von grossen Epizentren ausgehenden Erdbebenwellen über die Erdoberfläche hin in systematischer Weise verfolgt werden könnte. Als unerlässliche Ergänzung des vorgeschlagenen Beobachtungssystems betrachteten wir die Begründung und Unterhaltung einer Zentralstelle für die Sammlung und Veröffentlichung von seismischen Beobachtungen aus der ganzen Welt. Diese Vorschläge habe ich, unterstützt von Geheimrat Dr. von Neumayer, Professor Dr. F. A. Forel and Dr. James Murie, dem VII. Internationalen Geographen-Kongress zu Berlin vorgelegt, welcher sie in einer Schlussresolution billigte. Sie wurden alsdann in deutscher und französicher Sprache gedruckt und an alle Erdbebenforscher sowie eine grosse Anzahl von Gelehrten verschickt.

Aber trotz der Gutheissung der Vorschläge durch den Geographen-Kongress und trotz der zustimmenden Erklärung seitens der Delegirtenversammlung der kartellierten Akademien sowie einer grossen Anzahl hervorragender Forscher kam der Gedanke keinen Schritt der Ausführung näher. Es fehlte der Mittelpunkt, von dem die Anregung ausgehen musste und an den sich die geplanten Stationen anlehnen konnten. Ein solcher wurde im Jahre 1899 durch die Gründung der kaiserlichen Hauptstation für Erdbebenforschung zu Strassburg

gegeben, die mit den vollkommensten Instrumenten ausgestattet wurde. Damit war die Möglichkeit geboten, der Frage nach der Gründung einer internationalen seismologischen Vereinigung von neuem näher zu treten. Denn nun war eine Zentralstelle für die Sammlung und Bearbeitung der internationalen seismologischen Beobachtungen geschaffen. Um ihr die Unterstützung aller Seismologen zu gewinnen und die seismologischen Forschungen zu organisieren und konzentrieren, legte ich dem VII. Internationalen Geographen-Kongress zu Berlin einen Aufruf zur Gründung einer internationalen seismologischen Gesellschaft vor, der gegengezeichnet war von den Herren Credner, Helmert, von Neumayer, von Richthofen, Supan und Wagner.

Der Zweck der Gesellschaft sollte sein:

1. Möglichste Beförderung der methodischen makroseismischen Untersuchung aller Länder, namentlich der noch stationslosen und daher seismisch wenig bekannten.

2. Möglichst einheitliche Organisation der mikroseismischen Beobachtungen.

3. Konzentration der Veröffentlichungen, die als selbständige Hefte der Beiträge zur Geophysik erscheinen würden.

Diese internationale Gesellschaft war gedacht als Vereinigung der seismichen Institute und Stationen aller Länder, in welchen Beobachtungen angestellt oder eingerichtet werden. Auf den alljährlichen Versammlungen sollten die Institute und Stationem oder, in besonderen Fällen, die einzelnen Länder durch Delegierte vertreten sein. Die Aufgabe der Delegierten-Versammlung sollte dahin gehen, von dem Stand der seismischen Forschungen in den einzelnen Ländern Kenntnis zu nehmen und weitere Vereinbarungen über die Methode der Beobachtungen und der Bearbeitungen des Materials zu treffen.

In seiner letzten Sitzung nahm der Internationale Geographen-Kongress den Antrag in folgender Fassung an:

Der Kongress spricht seine Zustimmung aus zu der Gründung einer internationalen seismologischen Gesellschaft und hält die Bildung einer permanenten Kommission für die internationale Erdbebenforschung für wünschenswert.

Der Kongress beauftragt die Geschäftsführung des Kongresses mit der Bildung einer solchen Kommission.

Die Konstituierung der internationalen permanenten Kommission für Erdbebenforschung erfolgte noch vor Schluss des Kongresses; ihr gehörten fast alle Unterzeichner des Aufrufes und eine Reihe anderer Gelehrter an. Durch Zuwahl vergrösserte sich später die Zahl der Mitglieder bis auf etwa fünfzig.

So waren denn nun alle vorbereitenden Schritte getan, welche notwendig waren, den schon seit langem gehegten Plan einer internationalen Erforschung der Seismizität der Erde ins Werk zu setzen und zu dem Zwecke eine internationale seismologische Vereinigung zu

gründen. Schon während des Kongresses war es möglich gewesen dem Herrn Staatssekretär des Innern, Grafen von Posadowsky, die Bitte vorzutragen, die Reichsregierung möge die Bestrebungen dadurch fördern, dass sie die auswärtigen Regierungen darauf aufmerksam mache und sie ersuche, dieselben durch Absendung von Delegierten zu den Versammlungen der internationalen Gesellschaft zu unterstützen. Die Aufnahme, welche diese Bitte fand, liess einen günstigen Erfolg voraussehen.

I. GRÜNDUNG DER INTERNATIONALEN SEISMOLOGISCHEN ASSOZIATION

Nach eingehenden Verhandlungen mit der Geschäftsführung des Internationalen Geographen-Kongresses sowie mit Vertretern des Reichsamts des Innern und des Preussischen Kultusministeriums erliess die Direktion der Kaiserlichen Hauptstation im Namen der internationalen permanenten seismologischen Kommission die Einladungen zu einer internationalen seismologischen Konferenz. Dieselbe tagte in Strassburg in den Tagen vom 11.–13. April 1901 und bestand aus Mitgliedern der permanenten Kommission, den Delegierten verschiedener Regierungen und einer Reihe von geladenen Gästen.

Den Hauptgegenstand der Beratungen bildete der von der Direktion der Kaiserlichen Hauptstation vorgelegte Entwurf von Statuten einer internationalen seismologischen Gesellschaft. Das Ergebnis der Verhandlungen ging dahin, dass hauptsächlich auf den Vorschlag der Delegierten Japans und Russlands hin die Gründung einer seismologischen Gesellschaft abgelehnt und der Abschluss einer internationalen seismologischen Assoziation der Staaten empfohlen wurde. Den Staaten sollte ein neuer Statutenentwurf unterbreitet werden, in welchem unter Anlehnung an die für die internationale geodätische Assoziation geltenden Bestimmungen die Funktionen der wichtigsten Organe der Assoziation dargelegt sind. Einem einstimmig angenommenen Antrage des Professors Dr. F. A. Forel (Schweiz) zufolge sollte die Deutsche Reichsverwaltung gebeten werden, diese Assoziation bei den anderen Staaten zu befürworten und die weiteren Schritte zur Vorbereitung eines Assoziationsvertrages zu tun. Der Kommissar der Reichsverwaltung, Herr Geheimer Oberregierungsrat Lewald, übernahm es bei dem auswärtigen Amt des Deutschen Reiches sich dafür zu verwenden, dass den auswärtigen Regierungen von den Beschlüssen der Konferenz Mitteilung gemacht und auch der neue Statutenentwurf übermittelt werde.

Da indessen zu erwarten war, dass noch ziemlich lange Zeit verstreichen werde, bis die diplomatischen Verhandlungen zu dem gewünschten Resultate führen würden, so regte Herr Helmert den Gedanken an, noch vor Abschluss der Assoziation mit den gemeinsamen Beobachtungen zu beginnen und zu dem Zwecke eine provisorische Zentralstelle zu bestimmen. Im Anschluss an die Verhandlun-

gen stellte Herr Forel einen von allen ausserdeutschen Mitgliedern der Konferenz unterzeichneten Antrag, mit den Funktionen dieser Zentralstelle vorläufig die kaiserliche Hauptstation für Erdbebenforschung zu betrauen. Der Antrag wurde einstimmig angenommen und der Direktor der Hauptstation erklärte sich bereit die Pflichten des Centralbureaus zu übernehmen. Um dem Zentralbureau die Ausübung seiner Funktionen zu ermöglichen, verpflichteten sich die Anwesenden, durch Einsendung ihrer Beobachtungen es zu unterstützen.

So war das Ziel erreicht, für welches sich auf dem Geographen-Kongress zu Berlin 1899 die internationale permanente seismologische Kommission gebildet hatte, und wenn auch die definitive Form und Anerkennung der Beschlüsse noch fehlte, so konnte doch die Aufgabe der permanenten Kommission als beendet angesehen werden. Deswegen stellte Herr Geheimrat Wagner im Auftrage der Geschäftsführung des VII. Internationalen Geographen-Kongresses den Antrag, die permanente Kommission, wie sie 1899 von Seiten des Geographen-Kongresses anerkannt war, für aufgelöst zu erklären. Damit aber die Verbindung mit dem Geographen-Kongress aufrecht erhalten bleibe, ergänzte er seinen Antrag durch den Vorschlag, an Stelle der grossen Kommission eine kleinere zu bilden, damit deren Mitglieder dem nächsten Internationalen Geographen-Kongress Bericht erstatteten und den formellen Uebergang in die neuen Verhältnisse in die Wege leiteten. Zu Mitgliedern dieser neuen Kommission schlug er vor die Herren Forel, Gerland, Helmert, von Kövesligethy, Lewitzky, Mojsisovics und Palazzo.

Den endgültigen Abschluss der Assoziation brachte die zweite internationale seismologische Konferenz, welche am 24. Juli 1903 in Strassburg zusammentrat. Die Deutsche Reichsverwaltung hatte der Bitte, welche ihr nach dem in der fünften Sitzung der ersten Konferenz gefassten Beschlusse vorgetragen war, entsprochen und an viele der in Betracht kommenden Staaten die Aufforderung gerichtet sich auf einer konstituierenden Versammlung durch Delegierte vertreten zu lassen. Die Aufgabe der Versammlung ging dahin, die Grundzüge eines Assoziationsvertrages aufzustellen sowie Abmachungen über die allgemein gültigen Grundsätze zu treffen, welche für die seismische Beobachtung in den assoziierten Staaten fortan massgebend sein sollten.

Der wichtigste Beratungsgegenstand war demnach der von der Direktion der kaiserlichen Hauptstation vorgelegte Entwurf einer Uebereinkunft betreffend die Organisation der internationalen Erdbebenforschung. Bei der Abfassung hatte als Muster die "Neue Uebereinkunft" gedient, welche die internationale geodätische Assoziation im Jahre 1896 abgeschlossen hat. Einzelne Bestimmungen derselben sind mit sinngemässer Abänderung in den Entwurf übernommen.

Die Grundlage aber bildeten die Statuten, welche aus den Beratungen der ersten internationalen seismologischen Konferenz im Jahre 1901 hervorgegangen waren.

Auf der Konferenz waren folgende 20 Staaten durch Delegierte vertreten:

Deutsches Reich, Argentinien, Oesterreich, Ungarn, Belgien, Bulgarien, Chile, Kongo-Staat, Vereinigte Staaten von Amerika, Grossbritannien, Japan, Italien, Mexiko, Niederlande, Portugal, Rumänien, Russland, Schweden, Schweiz. Der Delegierte Serbiens war verhindert an der Konferenz teilzunehmen.

Nach eingehenden Verhandlungen wurde die "Uebereinkunft" einstimmig am 27. Juli angenommen. Der letzte Artikel setzt fest, dass die Uebereinkunft zunächst auf die Dauer von zwölf Jahren, beginnend mit dem 1. April 1904, geschlossen ist. Sie gilt für jeden der beigetretenen Staaten auf je vier Jahre verlängert, wenn nicht mindestens sechs Monate vor Ablauf dieser Periode eine Kündigung erfolgt. In einer vom dem Schweizer Delegierten Herrn Forel vorgeschlagenen Resolution, welche allgemeine Zustimmung fand, wurde die Deutsche Reichsverwaltung gebeten, die Uebereinkunft auch denjenigen Regierungen zu übermitteln, welche auf der Konferenz nicht durch Delegierte vertreten waren.

Die Reichsverwaltung hat auch diesesmal der Bitte der Konferenz entsprochen und die Beschlüsse der Konferenz sowie die Uebereinkunft den Regierungen aller bei der Erdbebenforschung interessierten Staaten zugehen lassen. Die Mehrzahl der Staaten hat bis jetzt ihre Zustimmung zu den Beschlüssen ausgesprochen, ihren Beitritt zur Assoziation erklärt und ihre Delegierten zur permanenten Kommission namhaft gemacht. Mit dem Zusammentreten der permanenten Kommission, welche demnächst ihre erste Tagung abhalten wird, werden in den assoziierten Staaten die seismischen Beobachtungen nach gemeinsamen Grundsätzen ihren Anfang nehmen.

II ORGANISATION DER INTERNATIONALEN SEISMOLOGISCHEN ASSOZIATION.

Die Assoziation ist eine Vereinigung von Staaten zum Zwecke der Förderung aller Aufgaben der Erdbebenforschung.

Als hauptsächlichste Mittel hierzu dienen:

(a) Beobachtungen nach gemeinsamen Grundsätzen.

(b) Experimente für besonders wichtige Spezialfragen.

(c) Gründung und Unterstützung seismischer Observation in Ländern, welche die Beihilfe der Assoziation bedürfen.

(d) Organisation eines Centralbureaus für Sammlung, Bearbeitung und Veröffentlichung der Berichte aus den verschiedenen Ländern.

Jeder der Assoziation beigetretene Staat verpflichtet sich für die ... der Assoziation einen Jahresbeitrag zu leisten.

Die Höhe der Beiträge wird unter Zugrundelegung der Bevölkerungszahal nach bestimmten Abstufungen bemessen.

Organe der Assoziation sind:

(*a*) Die Generalversammlung.

(*b*) Die permanente Kommission.

(*c*) Das Zentralbureau.

Die Generalversammlung besteht aus den Delegierten de assoziierten Staaten. Sie tritt mindestens alle vier Jahre zusammen. Die Einberufung geschieht unter Zustimmung der permanenten Kommission durch den Präsidenten derselben. Dieser kann auch Präsident der Generalversammlung sein.

Wissenschaftliche Gesellschaften, Akademien und Institute, welche sich mit Seismologie beschäftigen, können auf ihren Antrag durch den Präsidenten der permanenten Kommisson ermächtigt werden, sich durch Delegierte mit beratender Stimme auf der Generalversammlung vertreten lassen. In gleicher Weise kann der Präsident der permanenten Kommission Einladungen zur Teilnahme an den Generalversamlungen erlassen.

Die permanente Kommission besteht aus dem Direktor des Zentralbureaus und aus dem von jedem Einzelstaat ernannten Mitglied. Die permanente Kommission wählt aus ihrer Mitte ihren Präsidenten, ihren Vicepräsidenten und den Generalsekretär.

Die Stelle des Präsidenten der permanenten Kommission und des Direktors des Zentralbureaus dürfen nicht in einer Person vereinigt sein.

Die permanente Kommission erledigt die Geschäfte in Zusammenkünften oder auf schriftlichem Wege. Sie bestimmt ihre Geschäftsordnung selbst. Sie sorgt für die Ausführung der Beschlüsse der Generalversammlung und für die diesen Beschlüssen entsprechende Verwendung der Beiträge.

Die Beiträge der assoziierten Staaten und sonstige Einnahmen können verwendet werden für:

(*a*) Die Publikationen und die Verwaltung der Assoziation.

(*b*) Die Entschädigung des Generalsekretärs.

(*c*) Die Unterstützung oder Renumerierung einschlägiger theoretischer oder experimentaller Arbeiten, welche durch einen desonderen Beschluss der Generalversammlung angeordnet wurden.

(*d*) Die Gründung und Unterhaltung der von der Assoziation errichteten Observatorien.

Die Verteilung der Beiträge auf die einzelnen Posten geschieht durch die permanente Kommission. Die Nachweisung über die Verwendung der Beiträge und sonstigen Einnahmen wird in den Sitzungsberichten der permanenten Kommission veröffentlicht.

Das Zentralbureau ist mit der Kaiserlich Deutschen Hauptstation für Erdbebenforschnng zu Strassburg in Elsass in solcher Weise ver-

bunden, dass der Direktor derselben zugleich Direktor des Zentralbureaus ist und dass die Arbeitskräfte und Mittel der Hauptstation auch den Zwecken der internationalen Erdbebenforschung dienen. Das Zentralbureau sammelt die Berichte der einzelnen Länder, vereinigt sie zu allgemeinen Übersichten und veröffentlicht dieselben.

Der Direktor des Zentralbureaus hat dem Präsidenten der permanenten Kommission alljährlich einen zusammenfassenden Bericht über die Tätigkeit des Zentralbureaus zu erstatten und demselben den Arbeitsplan für das folgende Jahr zu unterbreiten. Sowohl der Bericht als auch der Arbeitsplan sind allen Delegierten der beteiligten Staaten gedruckt zuzusenden.

Der Generalsekretär gibt in jeder Generalversammlung einen Bericht über die Arbeiten und die Lage der Assoziation. Ausserdem hat der Generalsekretär die Sitzungsberichte der permanenten Kommission, die Verhandlungen der Generalversammlungen sowie etwaige im Auftrage der Assoziation ausgeführte Arbeiten zu veröffentlichen. Er führt die Korrespondenz und besorgt die sonstigen laufenden Geschäfte der Assoziation unter der Oberleitung des Präsidenten der permanenten Kommission.

Die näheren Einzelheiten der Organisation sind in der Übereinkunft enthalten.

III. AUFGABEN DER INTERNATIONALEN SEISMOLOGISCHEN ASSOZIATION

Zweck der Erdbebenbeobachtung ist die Erforschung der Seismizität der Gesamterde. Daraus ergeben sich die Aufgaben, welche den einzelnen zur Assoziation gehörigen Staaten sowie der Assoziation als solcher obliegen.

Die Staaten haben die seismische Eigenart ihres Gebietes zu erforschen, in erster Linie also die Erdbeben, welche in dem Lande selbst ihren Ursprung haben, die Lokalbeben.

Die erste und vornehmste Aufgabe der Staaten ist also die Errichtung eines Netzes von richtig verteilten Beobachtungsstationen und die Einrichtung eines seismischen Beobachtungsdienstes.

Es gibt drei Arten von Bodenbewegungen, welche erforscht werden müssen:

1. Makroseismische Bewegungen.
2. Mikroseismische Bewegungen.
3. Bradyseismische Bewegungen.

Die beiden ersten Bewegungsarten sind rein seismischen Charakters, letztere besteht in Schwankungen der Niveaufläche, wodurch Abweichungen der Lotlinie veranlasst werden. Alle drei sind lokaler Natur und können lokal beobachtet werden.

Entsprechend den verschiedenen Arten der Bodenbewegungen sind verschiedenartige Stationen einzurichten. Zunächst wird das Gebiet der Staaten in seismische Bezirke eingeteilt, die nach geographisch-

geologischen Gesichtspunkten abzugrenzen sind. Jeder Bezirk erhält eine Hauptstation und eine, je nach den Bedürfnissen verschieden grosse Zahl von Nebenstationen.

Die instrumentelle Ausrüstung jeder der beiden Arten von Stationen und ihre Arbeiten richten sich nach der Art von Bodenbewegungen, welche beobachtet werden soll.

Hauptaufgabe der Nebenstationen ist die Beobachtung der makroseismischen Bewegungen, d. i. der direkt fühlbaren Erdstösse. Zur Registrierung der Bewegungen dienen weniger empfindliche Instrumente, die leicht zu bedienen sind. Die Aufzeichnungen der Apparate liefern die wichtigsten seismischen Elemente, wie die Richtung der Bewegung, Periode und Amplitude der Wellen sowie die Dauer der Erschütterung. Ausserdem muss sich den Seismogrammen die zeitliche Bestimmung des Anfangs des Bebens und seiner einzelnen Phasen entnehmen lassen.

Die räumliche Ausdehnung der von einem Erdbeben erschütterten Fläche lässt sich mit Hülfe zahlreicher Beobachtungen festlegen. Deswegen bedürfen die Nebenstationen der Unterstützung durch Privatpersonen, welche sich verpflichten persönliche Beobachtungen vorkommendenfalls anzustellen. Die Einziehung solcher Mitteilungen ist die zweite Aufgabe der Nebenstationen. Um möglichst viel und möglichst zuverlässige Nachrichten über ein Erdbeben zu erhalten, empfiehlt es sich, besonders wissenschaftliche Institute wie Sternwarten, geologische, meteorologische, hydrographische Aemter und wissenschaftliche Vereine oder Gesellschaften für die Mitarbeit zu interessieren.

Den Nebenstationen kommt demnach eine wichtige Rolle in dem seismischen Beobachtungsdienste der Länder zu. Durch ihre Arbeit allein ist es möglich, der ganzen seismischen Forschung die unentbehrliche Grundlage zu geben, nämlich die räumliche Verbreitung des Auftretens der Erdbeben über die Erde hin und die Lage der Epizentren geographisch festzulegen.

Die Hauptarbeit der Hauptstationen ist die Beobachtung der mikroseismischen Bewegungen. Dieselben rühren meistens von Erdbeben her, die in weiter Ferne sich fühlbar gemacht haben und sich als elastische Schwingungen durch oder um die Erde fortpflanzen. In vielen Fällen sind sie auch auf kleine, lokal ganz beschränkte Beben zurückzuführen, die ihrer Entstehung nach noch vollkommen unbekannt sind. Eine dritte Art dieser Bewegungen sind die pulsatorischen Oszillationen, die durch die Einwirkung atmosphärischer Vorgänge veranlasst werden. Zur Beobachtung dieser drei Arten von microseismischen Bewegungen sind hochempfindliche Apparate erforderlich, deren Aufstellung und Bedienung grössere Sorgfalt nötig macht als bei den Nebenstationen. Dieselben Apparate genügen in den meisten Fällen zur Beobachtung der langsamen Schwankungen

der Niveaufläche, doch sind bei der Aufstellung besondere Einrichtungen notwendig, um die Apparate vor äusseren Einflüssen zu schützen.

Während die Nebenstationen nur beobachten und sammeln, liegt es den Hauptstationen ob, ihr eigenes Beobachtungsmaterial und das ihnen von den Nebenstationen gelieferte zusammenzustellen und zu bearbeiten. Eine Hauptstation wird in jedem Staate die Stelle eines nationalen Zentralbureaus erhalten und mit der Sammlung und Veröffentlichung der Forschungen betraut werden.

Für diejenigen Staaten, welche Seefahrt treiben, kommt noch die zweite Aufgabe hinzu, durch die Schiffe ihrer Kriegs- und Handelsmarine die submarinen Erdbeben beobachten zu lassen.

Die sogenannten Erdbebenflutwellen, welche häufig in Gefolge von submarinen Eruptionen auftreten und an den Meeresküsten grössere Verheerungen anrichten als die Erdbeben selber, machen die Aufstellung von Flutmessern an solchen Punkten notwendig, welche erfahrungsgemäss von Flutwellen heimgesucht werden.

Ist auf die angegebene Weise die seismologische Forschung organisiert und einige Zeit nach gleichen Grundsätzen in allen Ländern der Assoziation betrieben, so wird es möglich sein, sich ein Bild von der Seismizität eines jeden Landes und damit auch des grössten Teiles der Erde zu machen. Dann wird man erst ernstlich an Fragen herantreten können, die bei der bisherigen Art der Beobachtung und Forschung nicht gelöst werden konnten, so die Frage nach der Periodizität der Erdbeben, nach ihrer Frequenz in jedem einzelnen Gebiet, nach der Konstanz der Lage der Epizentren, nach den Beziehungen der Erdbeben zu tektonischen Linien, zu Gebirgen, Senkungsfeldern und Vulkanen, nach den Bedingungen für die Fortpflanzung, nach der Verbreitung der submarinen Erdbeben und der Entstehung der Erdbebenflutwellen, nach der räumlichen und zeitlichen Verbreitung der Vor- und Nachbeben, nach der Tiefe des Erdbebenherdes und damit auch nach der Ursache des seismischen Phänomens überhaupt.

Zu diesen Aufgaben, welche jeder einzelne Staat im besonderen zu erfüllen hat, kommen noch einige andere, welche die Assoziation als solche angehen. Dahin gehört als wichtigste die Einrichtung und Unterhaltung eines Zentralbureaus, ohne welches die organisierte seismologische Forschung nicht bestehen kann. Bei dem Zentralbureau fliessen die Forschungsergebnisse der einzelnen Länder zusammen und werden nach verschiedenen Gesichtspunkten zu allgemeinen Uebersichten zusammengestellt. Für einzelne Weltbeben werden eingehendere Darstellungen des Verlaufs der Störung an den verschiedenen Stationen gegeben.

Die periodischen Veröffentlichungen des Zentralbureaus enthalten ausser diesen regelmässigen allgemeinen Uebersichten auch noch die

Sitzungsberichte der permanenten Kommission und etwaige von einzelnen Forschern verfasste Abhandlungen seismologischen Inhalts.

Ausserdem hat das Zentralbureau ein ganz besonderes Augenmerk auf die Fortschritte in der Konstruktion der seismischen Apparate zu richten und die Erfahrungen, welche mit Apparaten und Einrichtungen gemacht werden, zur allgemeinen Kenntnis zu bringen. Die Anstellung einschlägiger theoretischer oder experimenteller Arbeiten kann durch die Assoziation veranlasst und pekuniär unterstützt werden.

Eine zweite nicht minder wichtige Aufgabe der Assoziation besteht in der Gründung und Unterhaltung seismischer Observatorien. Die zusammenfassenden Arbeiten, welche vom Zentralbureau besorgt werden, werden bald erkennen lassen, wo sich noch Lücken in dem seismischen Beobachtungsnetz der Erde befinden. Fehlen Stationen z. B. in solchen Ländern, welche nicht der Assoziation angehören oder welche nicht über die nötigen Mittel verfügen, so tritt die Assoziation durch Gründung und Unterhaltung der für die seismologische Forschung notwendigen Stationen helfend ein.

Endlich hat die Assoziation durch ihr wichtiges Organ, die permanente Kommission, darauf zu achten, dass die Beobachtungen nach gemeinsamen Grundsätzen angestellt werden.

THE LEWIS RANGE OF NORTHERN MONTANA AND ITS GLACIERS

By FRANÇOIS E. MATTHES, U. S. Geological Survey

[Abstract.]

The Lewis Range is the easternmost member of the Rocky Mountain system in northern Montana, and extends from the Canadian boundary line southeastward for 50 miles. Together with the Livingston Range (to the west) it is sculptured from a block of gently flexed sedimentary strata of Algonkian and Cambrian age, superimposed upon the Cretaceous strata of the Great Plains by a great overthrust in a northeast direction.

Its present aspect is that of a multitude of bold peaks and narrow comb ridges, separated by deep valleys of pronounced U-section. Glaciation is abundantly manifested, especially by the chains of lakes in the valleys and the numerous finely sculptured cirques at their heads. Many of the cirques still contain small glaciers and névé bodies.

Besides indications of a former surface of low relief, probably dating from pre-overthrust times, there are numerous scattered remnants of the later and more rugged type of topography which preceded the advent of the ice. It is probable that the elevated shelves and undulating tables (like West Flattop Mountain) are the glaciated remnants of valley floors dating from this period. The deep, narrow canyons which now dissect them appear to be the result of interglacial stream work. Most of the existing ice bodies are situated on these older surfaces and on narrow shelves which overlook profound cirques opening into the canyons.

Of the 36 ice bodies of the Lewis Range, brief descriptions are given of the following:

In the Belly River system, the Chaney and Shepard glaciers.

In the Swiftcurrent Creek system, the Grinnell and Swiftcurrent glaciers.

In the St. Mary River system, the Blackfoot and Sexton glaciers.

In the Nyack Creek system, the Pumpelly and Harrison glaciers.

In the MacDonald Creek system, the Sperry Glacier.

DISCUSSION

Mr. A. O. WHEELER desired to acknowledge the very large amount of information and pleasure he had derived from Mr. Matthes's lecture and the magnificent views accompanying it. One of the glaciers exhibited had reminded him forcibly of the Dawson Glacier in the Selkirk Mountains of British Columbia, on account of the regularity of its lateral moraines. The two lateral moraines of the Dawson Glacier looked like well-built levees, from 1 to 2 miles in width, containing a river of ice. Along the crest of these moraines lay a well-worn path, where flocks of wild goats were frequently seen traveling in single file.

Mr. H. F. REID commented on the truly remarkable cirques shown by Mr. Matthes, and suggested that the shelves which occur above the very deep valleys may represent an earlier rather than a later stage of erosion than that of the deep valleys themselves.

GLACIAL LAKES AND PLEISTOCENE CHANGES IN THE ST. LAWRENCE VALLEY

By Prof. A. P. COLEMAN, Toronto, Canada

INTRODUCTION

The succession of great lakes which followed the front of the Wisconsin ice sheet during its retreat toward the northeast has long been known, and it has been proved in all cases that their beach lines are no longer horizontal, but rise toward the northeast, indicating a differential elevation of the continent in that direction. Lake Warren and Lake Algonquin occupied the basins of the present upper Great Lakes, the former at a high level, the latter more nearly at the present level of Lake Superior. During the life of Lake Algonquin the basin of Lake Ontario also became freed from ice, though its outlet was still blocked, and Lake Iroquois was formed, receiving the waters of Lake Algonquin and emptying by the Mohawk Valley into the Hudson.

Later came a lake which may be named Quinte, from the bay on the northeast side of Ontario, where its beaches are best preserved. This had its outlet along the south shore of the St Lawrence through the Champlain Valley into the Hudson, the northern bank of the river having been apparently of ice. Later this lake may have expanded northeastward beyond the outlet into Lake St. Lawrence, as it has been named by Mr. Warren Upham, but up to the present its beaches have not been traced.

The Gulf of St. Lawrence presently obtained access to the region by the further melting of the ice front, and deposits containing sea shells were formed as far west as Brockville and as far up the Ottawa as Lake Coulonge. At this time Lake Ontario stood at the level of the sea, but was connected with the enlarged Gulf of St. Lawrence by a narrow and shallow strait a little west of Brockville, so that the flood of fresh water coming into it from Niagara probably prevented it from becoming salt.

Last of all the land rose so far that Lake Ontario was completely cut off from the sea, and the St. Lawrence began to flow at the Thousand Islands. The continued northeasterly elevation of the land has raised Lake Ontario 246 feet above sea level, and the differential

elevation, as shown by Dr. G. K. Gilbert, is almost certainly still progressing.

The succession of ancient shore lines briefly sketched above is accepted by practically all Pleistocene geologists who have worked in the region, and it is also admitted by all that they ascend toward the northeast, owing to greater elevation of the region in that quarter.

A few geologists have believed, and perhaps still believe, that the bodies of water which formed the raised beaches were arms of the sea, and that each shore line was formed at sea level; but freshwater shells have been found in deposits belonging to several of the ancient beaches, and in at least one, the Iroquois beach, the warping of the ancient shore corresponds to the position of an old outlet, proving that the sheet of water stood above sea level.

There has been some difference of opinion as to whether the differential elevation toward the northeast was continuous from the first, or whether it was intermittent, a given beach corresponding to a long halt in the process, or whether most if not all of the northeasterly elevation has taken place since the time of Lake Iroquois. In the opinion of the writer the elevation has been in progress during the whole period of the ancient great lakes.

If the bodies of water were fresh, the only dam competent to cut them off from the sea must have been the ice of the glacier, which as it retreated liberated lower and lower outlets. During the withdrawal of the ice, however, the northeasterly elevation was under way, complicating the relationships; and it may be that each of these vanished lakes began not far above sea level.

To illustrate the changes undergone by these old shores during and since the time of their formation, the most completely studied of them, that of Lake Iroquois, may be taken up in detail.

CHANGES IN THE SHORE OF LAKE IROQUOIS

Lake Iroquois was roughly mapped by Dr. G. K. Gilbert in New York State and Dr. Spencer in Ontario about sixteen years ago, the elevation of many points on the shore was determined, and it was shown that the beach was deformed.[a] Since then work has been done upon it by Professor Fairchild[b] and the present writer,[c] and the latest results are briefly as follows:

The beach has been traced around the basin of Lake Ontario, except over a stretch of about 100 miles on its northeast side, where the shore was of ice. The outlet, as shown by Dr. Gilbert, extended past Rome, N. Y., through the Mohawk Valley, into the Hudson; and the beach

[a] Sixth Ann. Rept. Commissioners State Reservation, Niagara, 1890, p. 67 et seq.; and History of the Great Lakes, Chap. IV, p. 44 et seq.

[b] Pleistocene Geol. Western New York, Rept. Progress, 1900, p. r. 107.

[c] Bull. Geol. Soc. Am., Vol. XV, pp. 347-368; also Rept. Bur. Mines of Ontario, 1904, Part I, p. 225, etc.

is a unit from Rome westward to Hamilton and northeastward to a point a few miles north of Port Hope, half way along the northern side of Lake Ontario. From Rome northward and from Port Hope northeastward the shore is split up into several beaches which, in Ontario at least, diverge.

The old shore is 116 feet above Lake Ontario at its southwest end near Hamilton, and 311 feet above it north of Port Hope, the direction of elevation being about north 20° east, and the amount 2 feet per mile in the southwest half, from Hamilton to Toronto, and 3.4 feet per mile between Toronto and Port Hope. Beyond the last point, which, like Rome in New York, is on the pivot about which the water level swung, the beach splits up. The lowest well-marked gravel bars give a rate of elevation in the direction north 20° east of 4.17 feet per mile; the highest a rate of 7 feet per mile.

Southwest of the pivot line the beach above referred to is, of course, the latest, and earlier stages should theoretically be buried beneath it. Evidence of land surfaces has been found at Toronto and Hamilton down to 70 or 80 feet below the latest Iroquois beach. At Hamilton an old soil with trees has been disclosed 32 feet below the top of an Iroquois bar, and mammoth tusks and bones, not waterworn, occur 83 feet below the same level. If the divergence of the beaches northeast of Port Hope continued to the southwest at a rate proportional to the deformation of the highest beach, the earliest water level should be 139 feet below the latest.

From the evidence briefly given above it is clear that the tilting of the land was in progress during the life of Lake Iroquois, the deformation between the extreme points of the old shore during the existence of the body of water being not less than 140 feet and probably as much as 250 feet, or even more.

Since Lake Iroquois was drained the deformation has continued, so that the latest beach shows a difference of level between its extreme ends, at Hamilton and on an island near West Huntingdon, of 380 feet. If the northeasterly elevation progressed uniformly from the beginning of Lake Iroquois to the present, the life of that lake extended over two-fifths of the whole time. That the deformation is still going on seems very probable from Dr. Gilbert's work on the present lake levels, but the rate of elevation may have lessened.

RELATION OF ICE SHEETS TO CHANGES OF LEVEL

The cause of the changes of level which have just been referred to is generally considered to be the variation in load due to the formation and removal of an ice sheet in the region. Before the Ice Age the land stood at a higher level than now, as is shown by old river channels traced by soundings beneath the present level of the sea in the Gulf of St. Lawrence and elsewhere. The ice accumulated in Labra-

dor to the thickness of thousands of feet, and the land sank beneath the burden. Finally, the load was lifted by the thawing of the great ice mass (the Wisconsin sheet) and the land began to rise again. As the ice was thickest in southern Labrador and northern Quebec, that part of North America sank lowest under its load, and has risen higher and more rapidly than surrounding regions since the removal of the ice. Accordingly we find in that direction a greater elevation of the Iroquois and other old beaches southeast of Labrador.

There are some points of importance in regard to the relation between the removal of the load and the progress of the resulting elevation. It might be supposed that isostatic equilibrium would be preserved during the whole process, the sinking or rising of the land corresponding exactly to the changing load; so that, for example, the piling up of 5,000 feet of ice would immediately result in a sinking of the land to the extent of 1,850 feet, and its removal would be straightway followed by an elevation of 1,850 feet. According to this view any halt in the retreat of the ice sheet should be accompanied by an equivalent cessation of elevation; and, further, when the whole of the load of ice had melted the elevation should come to an end.

That there is no such sharp correspondence between the load and the level of the land is proved by the continuance of the northeasterly elevation up to the present, long after the Wisconsin ice sheet has vanished. Lake Ontario, for instance, is now backing up its waters toward the southwest because of the relative rise of its outlet at the Thousand Islands. The water of Hamilton Bay behind the great Burlington beach is now 78 feet deep, and all the rivers have dead water in their lower reaches, the Niagara having a depth of 72 feet. It is clear, then, that the response of the earth's crust to change of load is somewhat sluggish, the effect lagging hundreds or thousands of years behind the cause.

INTERGLACIAL CHANGES OF LEVEL

The changes of level connected with the retreat of the Wisconsin ice sheet have been indicated above; but this region has been invaded by ice more than once, and long-continued interglacial periods have separated the glacial periods. The best recorded interglacial period in America is that of the Toronto formation, which includes great delta deposits formed by the Laurentian River which drained the valleys of the upper Great Lakes from Georgian Bay to Scarboro Heights, north of Lake Ontario. The Wisconsin ice sheet piled a moraine several hundred feet thick across this old valley, so that the present circuitous drainage by Lake St. Clair and Niagara Falls came into use.

The exact chronological position of the Toronto interglacial formation is not settled. It has generally been considered to occupy the

interval between the Iowan and Wisconsin ice sheets; but some good authorities place it just after the Illinoisan ice age. That it is interglacial, however, is undisputed.

The delta deposits begin with stratified sand and gravel containing wood and unios at one point 40 feet below the present level of Lake Ontario, so that we start with the Laurentian River flowing into the Ontario basin at a lower stage of water than now. Afterwards the water rose till it was 60 feet above the present lake, depositing in a delta several miles wide sand and gravel and clay with tree trunks and shell fish such as now live in the Mississippi.

The climate up to this stage, as shown by the 38 species of trees, was as warm as that of Ohio or Pennsylvania, so that there is no question of an ice dam for the lake. It must have been held up by warping at the outlet, as at present, but at a greater elevation than now.

The water of the interglacial lake ultimately rose 185 feet above the present level, the river depositing stratified clay and sand to that depth and forming a delta more than 20 miles wide. The remains of trees and other plants and of 70 species of extinct beetles found in the delta clay indicate that the climate had become cooler, like that of the north shore of Lake Superior or of the lower part of the St. Lawrence.

The water was then drained off to a depth considerably lower than the present Lake Ontario, and the Laurentian River and its tributaries that of cut valleys more than 185 feet deep and a mile or more in width from rim to rim. This sinking of the outlet of the interglacial lake was probably caused by the accumulation of the next ice sheet in the Labrador region, before it had advanced far enough, however, to cross the St. Lawrence Valley and hold back its waters.

The next change, as recorded at Scarboro Heights, was the occupation of the Ontario basin by ice, which covered the surface of the delta and of the valleys cut in it with a sheet of bowlder clay. Above the bowlder clay, which follows the contours of the old land surface, lies stratified clay followed by stratified sand up to about 200 feet above Lake Ontario, indicating a recession of the ice and the formation of a glacial lake. Above this the section shows three other sheets of bowlder clay, separated by stratified sand and clay, proving that there were three advances and retreats of the ice. The stratified material, which underlies the bowlder clay forming the present surface of the country, reaches a height of about 340 feet above Lake Ontario to the north of Toronto; and this, so far as known, was the highest level attained by the glacial waters of the region.

One of these beds of stratified sand is very extensive and has been followed from Toronto northeastward to Cobourg, a distance of 50 miles, so that most of the basin of Ontario was free from ice at the time, and a lake comparable to Lake Iroquois, but more than twice as

deep, must have existed for hundreds or thousands of years. We have no means of determining the level of these bodies of water above the sea, but while the ice sheet occupied all the region to the northeast we may suppose that the land stood much lower than now.

From the foregoing statements it will be seen that the interglacial period contained episodes like those which have taken place since the Wisconsin ice began its retreat, but of a more complex nature.

SUCCESSION OF EVENTS IN INTERGLACIAL TIMES

If we take the interglacial period shown in the Toronto and Scarboro deposits as a whole and include events which are unrecorded in the strata but which must have taken place, we shall have a complete cycle of changes between one glacial period and the next following one. With the retreat of the ice sheet before the Toronto interglacial period the St. Lawrence basin must have been gradually set free from its icy bondage much as it was during the retreat of the Wisconsin sheet, forming a succession of lakes corresponding in many ways to lakes Warren, Algonquin, and Iroquois, but with this important difference, that the drainage of the upper lakes was through the Laurentian River from what is now Georgian Bay to the Ontario basin. The interglacial predecessor of Lake Iroquois had no Niagara pouring into it, but sent a bay toward the north from Toronto and Scarboro to meet the Laurentian River.

When the Illinoisan or Iowan ice sheet finally vanished the land stood lower than it does now, though perhaps not lower than the level of Lake Ontario in its earliest stages after the Wisconsin ice disappeared.

The removal of the load of ice was at length followed by a rise of the land toward the northeast that dammed back the Laurentian River and forming an interglacial Lake Ontario, which not only equaled Ontario in depth, but became gradually deeper as its outlet was elevated, until it reached 185 feet above the present level. The Laurentian River piled up its delta deposits to correspond with the height of the lake as it rose.

At length equilibrium was reached and the region to the northeast ceased to rise.

The next glacial period began and the Labradoran ice cap slowly thickened and spread outward in all directions, the land at last sinking beneath its weight, so that the Laurentian River could cut a deep valley in its own delta. Finally, the encroaching ice dammed back its waters, forming a succession of what may be called pre-Glacial lakes at various levels up to 340 feet above Ontario.

CONCLUSIONS

It is entirely possible that we are now living in an interglacial period, and that the latter part of the series of events sketched above is to be repeated in the future. If so, Lake Ontario will continue to deepen for thousands of years, till at last Toronto and Hamilton are submerged beneath its waters and the land to the northeast stands hundreds or thousands of feet higher than at present. Meantime the climate will have become cooler, and ultimately nevé and ice will accumulate and the next glacial period will have begun.

However that may be, a comparison of the interglacial water levels with post-Glacial ones shows that the parallelism between the two series of water levels is a striking one, indicating that sinkings and risings of the land in connection with the accumulation and the dissipation of ice sheets have occurred in a rhythmic way at least twice and possibly several times in the Pleistocene history of the Great Lakes region.

The slowness of the response of the earth's crust to a change of load is one of the interesting features brought out by the investigation, the completion of the upward or downward movement apparently demanding thousands of years after the inciting cause has ceased to act. The bearing of this fact on the conditions existing in the layer beneath what we are accustomed to call the "earth's crust," or the lithosphere, is evident, for the adjustment must take place by the slow outward flow of material from beneath the loaded part, and an equally deliberate return movement after the load has been removed. Evidently, the plastic layer requires much time to accomodate itself to the change of load in either direction, and to our customary tests of rigidity would probably react as a very resistant solid. The depth at which these movements take place and the mechanism by which they are accomplished need not be discussed here, since they belong to the domain of physics.

The accident of a chain of great lake basins, draining northeastward in such a way as to be interrupted by advancing or retreating ice sheets, has provided an unusually sensitive indicator of changes of level in northeastern America, but there is every reason to believe that other parts of the world which have been invaded by great ice masses have undergone an equally complex series of changes in Pleistocene times.

THE RESERVOIR LAG IN GLACIER VARIATIONS

By HARRY FIELDING REID, Johns Hopkins University, Baltimore, Md.

It has been shown, particularly by the work of Finsterwalder, that when variations occur in the length of glaciers there is a thickening of the glacier in the upper part, that this thickening progresses like a wave downward, and the glacier advances when it reaches the end. This necessarily implies that the advance of the end occurs some time after the glacier thickens in its upper part. It may also be shown that the thickening in the reservoir does not keep pace with the variation in accumulation, but that it lags behind it, in general, by nearly one-fourth of a period. Perhaps the simplest way to form a clear conception of this phenomenon would be to consider a vessel into which water is being poured, and in whose bottom a small hole had been made. If the supply is steady the vessel will fill up to such a point that the pressure will cause an outflow through the opening equal to the supply. If, now, the rate of supply is increased by a small amount the water will rise in the vessel and will gradually approach a new position of equilibrium, but will only reach it after an infinite time, the increasing depth following an exponential curve. In this simple case we see it takes a long time for the new adjustment to be brought about. If, now, there is a variable change in the rate of supply the depth of water in the vessel would seek to adjust itself to the new rate, but would never reach an adjustment. If we take the special case in which the rate of supply varies periodically we should also find the depth varying periodically, but always lagging behind the supply.

Although the law which controls the flow of ice from the reservoir, as dependent upon the thickness of the ice, is not the same as the law governing the flow through the opening in the vessel mentioned above, still they are of the same general character, and the changes are of the same general nature. If, therefore, we have a periodic change in the rate of supply of snow in the reservoir, we shall have a periodic change in the thickness of the reservoir and in the rate of flow from the reservoir, which depends upon the thickness at the névé line; but these latter changes will lag behind the changes in accumulation. For glaciers which are not too small, say such as are not less than 100

meters thick at the névé line, this lag can be shown mathematically to lie somewhere between one-fifth and one-fourth of the period. This large lag comes from the fact that the small change in the rate of the annual supply would produce a much greater change in the thickness of the reservoir; so that when the rate of supply is increased, passes through maximum, and diminishes again, the reservoir increases in thickness until the rate of supply has very nearly reached its original value, and then it begins to diminish; so that it reaches its maximum only a short time before the rate of supply has come back to its average value. The lag varies in different glaciers, according to their size, approaching a quarter period in large glaciers, and not differing greatly from that unless the glacier is quite small.

When the reservoir is in the neighborhood of its maximum thickness, the changes are practically proportional to the changes in the rate of supply. In a typical example, therefore, the maximum thickness, which occurs when the rate of supply is changing rapidly, exists but for a short time; whereas the minimum thickness, which occurs when the rate of supply is changing more slowly, exists for a much longer time.

We conclude, therefore, that the advance of a glacier not only lags behind the increase in snowfall on account of the time necessary for the increased thickness to travel like a wave down the glacier, but that this increased thickness in the reservoir itself lags nearly a quarter period behind the increase in snowfall which produces it.

MATHEMATICAL DEMONSTRATION

Given a glacier which is in equilibrium—that is, in which the annual accumulation of ice in the reservoir equals the annual flow through a section at the névé line, and this equals the annual melting in the dissipator—let the accumulation vary, what will be the corresponding variation in the depth of the reservoir and in the flow at the névé line?

We shall assume that the flow at the névé line varies as the fourth power of the thickness of the glacier at that line. This law is assumed because the average velocity and the area of the section may each be considered to vary approximately as the square of the thickness. It can readily be shown that any probable law will lead to the same kind of results as the one assumed, and for the majority of glaciers will not lead to very different values quantitatively. We shall also assume that the ratio of the variation in thickness at the névé line to the variation in the average depth of the reservoir is constant; the actual value of the ratio, which can never be greater than unity, is in most cases unimportant.

Let R=area of the reservoir;

F_1=normal flow at the névé line;

T_1=normal thickness at the névé line;

T_1+T=actual thickness at the névé line;
λ_1=normal depth of reservoir;
$\lambda_1+\lambda$=actual depth of reservoir;
a_1=normal annual accumulation in reservoir;
a_1+a=actual annual accumulation in reservoir.

Then for equilibrium we have the relations

$$Ra_1=F_1=kT_1^4$$

where k is the ratio of the flow to the fourth power of the thickness.

Expressing the fact that the difference between the accummulation and the flow equals the increase in the quantity of ice in the reservoir, we get the equation

$$R(a_1+)adt-k(T_1+T)^4dt=Rd\lambda$$

Let us suppose first that a is a constant; that is, that the annual accumulation suddenly increases by an amount a. Replace T by $m\lambda$, where m is a constant not greater than unity; and remembering that $m\lambda$ is small compared with T_1 we can develop the fourth power term and neglect the square and higher powers of $m\lambda$; we thus get

$$R(a_1+a)dt-k(T_1^4+4T_1^3m\lambda)dt=Rd\lambda \qquad \text{(I)}$$

The solution of this equation is

$$\lambda=\frac{aT_1}{4ma_1}\left(1-e-\frac{4ma_1}{T_1}t\right)$$

and we see that the reservoir increases in depth according to an exponential curve beginning at the rate of a per year and finally gets thicker by $T_1/8$ if $a/a_1=1/2$ and $m=1$. The thickness at the névé line increases by the same amount whatever be the value of m.

In the second place let us suppose that a is a periodic variation, which can therefore be represented by

$$\Sigma A_n \sin\frac{2\pi n}{\tau}t+\Sigma B_n\cos\frac{2\pi n}{\tau}t$$

where τ is the fundamental period, and n has all values from 1 to ∞. The solution of (I) then becomes

$$\lambda=C_oe^{-\alpha t}+\Sigma C_n\sin\frac{2\pi n}{\tau}t+\Sigma D_n\cos\frac{2\pi n}{\tau}t$$

where C_o is an arbitrary constant chosen so as to satisfy the initial or other arbitrary conditions; and

$$\alpha=\frac{4ma_1}{T_1}$$

If we write

$$C_n\sin\frac{2\pi n}{\tau}t+D_n\cos\frac{2\pi n}{\tau}t=E_n\sin\frac{2\pi n}{\tau}(+\varepsilon_n)$$

(we can call the second member the reservoir harmonic) we find

$$E_n = \frac{T_1 \tau \sqrt{A_n^2 + B_n^2}}{n\sqrt{16a_1^2\tau^2 m^2 + T_1^2(2\pi n)^2}}$$

If we take $a_1=2$ meters/years, $\tau=100/3$ years, $n=1$, $m=1$, we find the second term of the denominator 25 times as large as the first, which we can therefore neglect; indeed, with T_1 as small as 100 m the neglect of the first term would only introduce an error of 8 or 9 per cent in E_n. If m is less than unity, or if we are dealing with the higher harmonics, where n is greater than unity, the first term becomes still less significant; we can therefore write, with a fair degree of approximation,

$$E_n = \frac{\tau\sqrt{A_n^2 + B_n^2}}{2\pi n}.$$

Hence, so far as the amplitude E_n is concerned the choice of the proper value of m is unimportant.

The ratio of the amplitude of the reservoir harmonic to the accumulation harmonic diminishes proportionally to the order of the harmonic; hence the reservoir and flow variations approach more nearly a simple harmonic than the accumulation variation.

If $2\pi\, e_n\, n/\tau$ represents the difference of phase between the accumulation harmonic and the reservoir harmonic; this may be called the lag of the latter; its latter values will be given by

$$\tan 2\pi e_n\, n/\tau = 2\pi T_1/4a_1 m\tau.$$

The tangent of the lag is proportional to the order of the harmonic, but the actual lags will not differ greatly if that of the fundamental period approaches 90°. As an example, take $T_1=200\ m$; $a_1=2\ m/$yr., $\tau=100/3$ yr., and $m=1$; then

$$\tan 2\pi e_n n/\tau = 3\pi\, n/2,$$

which equals 4.72, 9.44, 14.16, etc., for $n=1$, 2, 3, etc., respectively; and the lags of the fundamental and higher harmonics are above 78°, 84°, 86°, etc.

Probably all fair-sized glaciers are thick enough at the névé line to have a reservoir lag of 70° or 80° for the fundamental period and a slightly greater lag for the harmonics. The fact that the lags of the various harmonics approach one-quarter of their periods and are not all equal in actual amounts causes a difference in form between the accumulation curve and the reservoir depth curve.

If our glacier should be very broad instead of having a narrow tongue we may put the flow at the névé line

$$Ra_1 = k\, T_1^3.$$

Calculating as above, we find the same value for E_n, and the tangent of the lag becomes 4/3 as great as in the former case for the same thickness, etc.

We get similar results if we assume no special law between the flow and the thickness at the névé line, but merely assume that the flow can be expressed as a function of the thickness which may be developed in powers of the thickness.

The interesting result of this investigation is that the lag in the variation of a glacier behind the variation of snowfall begins even in the reservoir, and in that part of the glacier will lie between a fifth and a quarter of the period, except for very small glaciers, when it will be less.

We have assumed that the variations of the thickness in all parts of the reservoir, and therefore also at the névé line, are isochronous. This is probably not strictly true, but it is more probable that the variations at the névé line are a little behind those of the upper part of the reservoir, this difference being greater if the reservoir is long and narrow than if it is short and broad.

DISCUSSION

Mr. MATTHES: Have any systematic observations been made with a view to determining the rate of advance of the "waves" referred to in the paper? Have the rates for glaciers of different widths been compared; and if so, does there seem to be any relation between rate and width?

Professor REID, in answer to Mr. Matthes: No investigations have been made, to my knowledge, seeking to establish such a relation.

THE GLACIERS OF MOUNT HOOD AND MOUNT ADAMS

By HARRY FIELDING REID, Johns Hopkins University, Baltimore, Md.

[Abstract.]

This paper consisted of a short account of the glaciers on these mountains, illustrated by lantern slides.

The most important result reached was that the streams at the end of the glaciers were eroding very strongly the soft material of which the mountains are composed; whereas, under the glaciers and under the permanent snow fields the water can not collect in well-defined streams, and here no erosion was observable. On Mount Hood, in particular, the glaciers rest on the flanks of the mountain, with no well-marked valleys, but where the ice or snow terminates the streams have eroded very deep canyons.

GLACIAL EXPLORATION IN THE MONTANA ROCKIES

By Prof. L. W. CHANEY, Northfield, Minn.

Between the Great Northern Railway and the international boundary in Montana lies a mountain region of surpassing interest. The figures which tell elevation above sea do not always represent the impressiveness of a mountain range. These Montana mountains rise from the Great Plains with an immediate and vast uplift which gives a very striking effect of loftiness and precipitancy.. It adds much to the effect that the valleys, especially those facing eastward, have been so broadened at the bottom by the gigantic glaciers of former times that the ridges between them take the form of lofty and almost vertical walls. The long front range of the Rockies, called the Lewis, extends northward to a point just beyond the international boundary, there terminating very abruptly. Parallel with this is a range called the Livingston. Between the two ranges, where the Livingston is already losing itself in irregular forest-covered hills, lies Lake McDonald at an altitude of 3,144 feet above sea.

In 1894 the Great Northern Railway adopted on its maps the name Glacier Lake for Lake McDonald. This was done without further warrant than the report of some tourists that the waters of a creek falling into the eastern side showed that milky color usually attributable to glacial detritus. About the same time a small hotel was erected and designated Glacier Hotel.

Having given a name to the lake and encouraged the building of the hotel, the railway company was interested in discovering some more definite basis for this nomenclature.

Dr. L. B. Sperry, of Oberlin, Ohio, who had been for some years a student and visitor of the western mountains, proposed to the railway company to make some explorations, and his proposition was well received. Having been invited to accompany Doctor Sperry in this glacier hunt, I undertook to discover what had already been published regarding the region. I could find nothing except an account by Mr. George Bird Grinnell of his trip in 1891 to the St. Mary Lake country, lying east of the Lewis Range. Mr. Grinnell had prepared a sketch map of the region and from this the military department had prepared a small blueprint upon cloth. This map showed scarcely a trail beyond the Lewis Range.

After the publication of my first paper in Science (of December, 1895), a communication of Mr. G. C. Culver to the Wisconsin Academy of Science came to my knowledge. Mr. Culver accompanied an expedition led by Lieutenant Ahern, U. S. Army, which entered the mountains from the east. Mr. Culver did not visit any of the glaciers, but upon the military map above referred to a glacier is shown under the name Culver Glacier. This has not since been identified.

Professor Pumpelly crossed these mountains in 1883 by what is now known as Cut Bank Pass, but published nothing, so far as I can ascertain.

I may complete the statement regarding general explorations by saying that Doctor Sperry has each year since 1894 spent some time in these mountains, and in 1896 succeeded in discovering the glacier which now bears his name. Mr. Grinnell visited the St. Mary Lake country in 1895, 1897, and 1898. A Government commission negotiating with the Blackfoot Indians for the surrender of the mountainous portion of their reservation carefully mapped the portion east of the Lewis Range. A map has been issued in connection with the survey of the Lewis and Clark Forest Reserve. Finally, the United States Geological Survey has issued a fine topographical map and an account of the geology of the region.

When, in 1895, our party entered the valley between the ranges, it was a land unknown except to prospector and hunter. A year earlier Dr. Sperry had pushed up the valley of McDonald Creek, and turning eastward had found the valley now called Avalanche Basin—the most magnificent of the once glacier-filled cirques in which the region abounds. In order to secure some measurements of the lake which lies at the bottom of Avalanche Basin and of the height of the surrounding mountains our party carried in a transit. The picturesque language which the tripod of our instrument evoked from the packers when they tried to secure it upon the animals was a feature of the expedition.

After ten days of climbing among the rocks and wading in the chill waters of the lake we had sufficient data for the calculation of various dimensions. It has interested me to note that these dimensions have been since almost exactly verified by the careful work of the Geological Survey. During this time various members of the party scaled the wall of the basin in the effort to reach the shelf at the eastern end, where must lie the glacier from which came the roaring cataracts that foamed down the cliffs. Although we reached the rim of the basin at several places, we were each time debarred from the desired position by pinacles of rock, over or around which we could, in the time at our disposal, find no passage. The distant view disclosed what seemed beyond question a glacier, but proof by direct

examination we still lacked. Wishing to extend our reconnoissance farther northward, we could not prolong our stay.

Leaving Avalanche Basin, we pushed northward between the two ranges. Two days' travel brought us to a huge, rounded, sparsely wooded mountain, known as Flattop. This mountain stands between the two ranges, and by way of it the continental divide shifts from one range to the other. Doctor Sperry having suffered a troublesome accident, we were glad to find the camp of some prospectors, which afforded a little more of the ordinary conditions of living than did our simple nomadic equipment.

Over the divide eastward is a glacier, said the miners.

In the early morning we began the climb. We noted as we passed the divide the aneroid reading of 8,400 above sea. A broad snow field was disclosed, and far down the slope long, curved lines of crevasses in glacier ice. The glacier is not large, but has some interesting features, and the surroundings are most rugged and impressive. During this visit and at later times Mr. Sheppard, photographer of the Great Northern Railway, secured some admirable pictures.

The cirque in which the glacier is inclosed opens eastward by an outlet not exceeding a quarter of a mile in width. Through this the ice river extends far down the mountain. I may not pause to describe the Glenns Lakes, each its own shade of blue, far down the valley, nor the flaming red of the quartzite which caps a mountain on either hand.

A second visit to the region occupied the season of 1903. It was our purpose to visit particularly the glaciers of the west side of the Livingston Range, including the Quartz Creek and the Agassiz.

The discovery of what seemed good oil properties near the boundary, in the vicinity of Kintla Lakes, had led to the opening of a wagon road from the foot of Lake McDonald to the lakes. We purposed to follow this road and to make side trips to the glaciers. We were not wholly successful. We obtained a good view of what we supposed to be Agassiz Glacier, but we were unable to reach it.

The Kintla Lakes were themselves the feature of this part of the trip. More beautiful sheets of water can not be imagined. They are surrounded by impressive mountains, and have shades and intensities of color not to be surpassed anywhere.

Passing the boundary into British Columbia, we were fortunate in taking an unintended trail, which led over a lofty and somewhat difficult pass instead of the easier but more prosaic one to which we had been directed. None of the party is likely to forget the brilliant August afternoon in which we reached the lofty summit and saw above us the vast arch of intense blue, and beneath our feet the blue, equally intense, of gentians and wild asters. On either hand sparkled on the higher slopes small glaciers, but none seeming worth the effort to reach them.

A day's ride down an interesting valley and we swung out onto the plains of Alberta and were confronted by the abrupt and varicolored cliffs of Goathaunt Mountains, the northern end of the Lewis Range. In a chink between it and the opposing peaks of the Livingstons lies Waterton Lake. Camping near its shores we had an opportunity to observe a primitive oil industry which has been carried on for some years in this region by a frontier character known as "Coal Oil Pete." He discovered the oil-bearing gravels and invented his process. The gravel was shoveled into huge plank tanks filled with water. The oil which then rose to the surface was laboriously skimmed off like cream from milk. This product he sold to his neighbors for lubricating purposes. The drilling of productive wells in the vicinity will doubtless terminate this method.

On both sides, as we pass southward between the ranges, are small glaciers from which creeks come down to the lake. Two days of travel brought us again to the vicinity of Chaney Glacier. Here we repeated and extended the observations made in the previous expedition. This second visit confirmed the opinion that its panorama of mountain, glacier, and lake is equal to anything in these mountains, and those familar with many lands hold it unsurpassed anywhere.

About midway from this point to Lake McDonald is an open, sparsely wooded park from which Grinnell Glacier is easily reached.

The limits of this paper have scarcely permitted more than an enumeration of the attractive localities in this region in which glacial studies may be prosecuted.

The various explorations to which reference has been made, particularly the final complete work of the Geological Survey, have served to make clear the aptness of the designation bestowed by a member of the survey—the Alps of America.

Returning to Lake McDonald we finished a circuit from which, by very reasonable expenditure of time and effort, a goodly portion of this majestic wonderland may be conveniently viewed.

DISCUSSION.

A. O. Wheeler said that he had listened to Professor Chaney's paper with very great interest and pleasure. During the present year he had paid a flying visit to the region described, and although he had not been able to travel into the heart of it, as Professor Chaney had done, he had seen sufficient to allow him to follow the Professor's vivid description with a greatly increased interest and understanding.

Professor Coleman remarked that the type of scenery shown in the lantern slides from the Montana Rockies is closely like that of the Rocky Mountains of Alberta to the north, though the amount of snow field and the extent of the glaciers increases as one goes north.

THE GLACIERS OF POTO, PERU

By OTTO F. PFORDTE, M. E., Rutherford, N. J.

Glacial action has played an important part in forming the present topography of a number of places in the Andes Mountains, not only directly but also indirectly, by redeposition of the glacial débris, whereby especially the enormous and sometimes gold-bearing gravel deposits on the eastern slope have been formed.

Most of the great glaciers which have done this enormous work in Peru have disappeared entirely, and in but few places do small portions of them still remain, exhibiting the phenomena attendant upon active glaciers. Near one of these, the glacier of Poto, the writer has spent some time, incidentally making a map of the neighboring region.

Poto is situated north of Lake Titicaca, at an altitude of 15,720 feet above sea level. It is one of the settlements founded by the Spanish conquerors when in search for gold, and judging by the large ruins of this village and those of neighboring places and by the amount of mining work done, this section must have been once a scene of great activity, and its former wealth is still shown in the meager remnants of skillfully carved woodwork and other architectural ornamentation on some of the buildings. At present this entire region probably does not contain more than 250 inhabitants, many of whom remain only during the favorable season. These natives are descendants of the Inca race and speak the Quechua language.

The highest mountain peak in this section is Ananea, about 9 miles northeast of Poto. The present glaciers, descending from the ice-covered summit of Ananea, flow in two general directions; one, the San Francisco, flows southwestward toward Lake Rinconada; the other, with a much broader face, flows southward, somewhat toward the east, in the general course of the former great glaciers.

The present San Francisco Glacier is located in a narrow gulch, about 1,500 to 1,600 feet in width, and now terminates at the head of a very steep precipice. On the south side of the glacier a lateral moraine has been deposited, which in some narrow places is 80 feet to 100 feet high, while in other wider sections the height of the moraine is reduced to 20 feet or 30 feet.

That the present face of the glacier has not varied much since the occupancy by the Spaniards is shown by the ruins of houses at the foot of the cliff where the glacier now terminates, although an old lateral moraine is distinctly visible at a small distance from the present one. Apparently the remnant of an old terminal moraine is seen at the head of Lake Rinconada; near it are also some ruins of houses.

The region directly southeast of Lake Rinconada consists of glacial débris, forming a low ridge about 200 feet to 400 feet high, which is sharply interrupted by a ravine at Poto and Viscachani; it formerly continued over the sites of these places to the mountains beyond, finally terminating at the western end of Ajollani.

The region north of Lake Rinconada consists of rather rugged mountains, covered with snow and ice in the higher sections and not showing any glacial débris, while the region west of the lake, toward Arequipa pampa, is a large open plain with an average grade of 2 per cent from the lake westward. This plain consists almost entirely of a secondary deposit and swamps near Lake Ajollani.

It is very probable that this plain was formed by a series of floods coming from Lake Rinconada and also from the shallow but large water basin of Pampas Blancas. This latter basin seems to have been once a large, somewhat triangular lake, which finally broke through the glacial deposit at its western shore, forming the ravine at Poto and Viscachani.

The fact that these deposits were formed by flood from two different directions is distinctly shown by at least two of the gravel strata, one of which has the characteristic reddish color of the mountains and of the foothills south of Pampas Blancas.

A strong flood occurring since the occupancy by the Spaniards is shown by ruins of a large stone tower, of unknown history, a short distance north of Poto. This tower is half buried in sand and small bowlders. The mountain range extending east and west south of Pampas Blancas has no perpetual snow or ice at present; but a series of foothills extending northward and consisting of glacial débris seems to indicate former glaciers. The three Purunani lakes, south of this range, probably formed one large lake formerly, draining toward the east, as is still shown by the drainage of the most easterly lake.

The Comuni Glacier is directly north of and feeds a small lake having the same name. The next glacier east and north of Cerro Morro Colla and the irregular glacier outline still farther east and north of Lake Morro Colla, once formed a single great glacier with a general southward trend through lakes Morro Colla and Trapiche and the hamlet of Trapiche. The lower end of the present Comuni Glacier is surrounded by an old, well-marked terminal moraine, averaging about 400 feet to 600 feet distant from its present line. This glacier seems

to have passed west of the small hill Morro Colla, which consists of débris much higher than any other near it, and about 600 feet above Lake Comuni. The glacier directly north of this hill extended several hundred feet deeper and passed to the east, in the direction of the small watercourse shown on the map, and, probably united with all the glaciers adjoining on the east, forming one great mass of ice, slowly flowing down the valley toward Trapiche. The small streams from the various lakes now uniting at Trapiche probably find their way finally into Lake Titicaca.

Pampas Blancas, consisting of gravel deposits, forms a large shallow basin, the bed of a former lake, its lowest section being the west end, its highest part on a general line drawn directly south of Lake Comuni. East of this line is a sharp decline in the contour of the gravel deposit down to the Trapiche and Morro Colla Valley. The eastern side of this valley is mainly a slaty rock without débris.

Undoubtedly a closer study of this glacial region would bring to light interesting facts that could be applied to other sections of the Andes Range. The neighboring mountains, distinctly stratified in some sections, are mainly composed of irregular slate containing quartz veins, the beds being of varying thickness. No volcanic rocks were noticed. Glacier striations were not observed in this region, but were found very well marked in a place about 20 miles north, where the amount of ice at present is very much less than at Poto.

The altitudes in the following table were taken with an aneroid barometer:

	Feet.
Lake Rinconada	15,730
Lake Purunani	16,400
Lake Morro Colla	15,840
Lake Trapiche	15,740
Lake Comuni	16,790
Lake Asnococha	16,950
Poto	15,720
Pampas Blancas	16,290
Trapiche	15,640
Viscachani	16,010
Old City Ananea	17,050
Ananea	[a] 20,000

The snow line in the mountain peaks of the Andes is gradually receding, judging by the testimony of old observers and some traditions of the natives, which mention some peaks now clear of snow which were formerly covered and others where the amount is very much reduced. This would consequently account for a decreased amount of flowing water and gradual lowering of the lakes in high altitudes.

It might seem that a scene like this is monotonous; on the contrary,

[a] Approximately.

it is ever changing. Although the outlines of the mountains and ice-covered peaks are fixed, the entire panorama which presents itself to the eye in this clear sky is one of sublime grandeur and one of almost constant change, owing to the variations of light and shade which are constantly taking place and are most rapid in the morning and evening. At the setting of the sun the shadows move speedily upward and after the last ray has vanished from the highest peak the entire enormous mass of ice is seen in a beautiful roseate tint from the refracted light of the departing day. At night, when the full moon, aided by the clear atmosphere, has caused the sense of distance to disappear almost entirely, the glaciers, mountains, plains, and lakes, resting in the white moonlight, and the deep shadows with the dark-blue sky above, aided by the absolute stillness of the night, form a panorama for which silent admiration is the only adequate expression.

THE MAGNETIC DISTURBANCES DURING THE ERUPTION OF MONT PELÉE ON MAY 8, 1902

By Dr. L. A. BAUER

Chief of Division of Terrestrial Magnetism of the Coast and Geodetic Survey and Director of Department of Terrestrial Magnetism of the Carnegie Institution of Washington

[Preliminary communication.]

Certainly one of the most remarkable phenomena connected with the great catastrophe which destroyed the town of St. Pierre on May 8, 1902, was the magnetic disturbance affecting magnetic needles over the whole earth at nearly the same time at all places and—as well as can be determined—simultaneously with the great eruption of Mont Pelée.

Previous magnetic disturbances doubtless have coincided with volcanic eruptions, but the information regarding them is either not so complete and definite as in the present instance, or the disturbances did not manifest themselves so abruptly and decisively as to immediately suggest some causal connection with a volcanic disturbance.

The present magnetic disturbances are furthermore especially interesting and unique, as apparently the only accurate determination of the time of the volcanic outbreak can be made with their aid. As is well known, the Mont Pelée eruption was not accompanied by such phenomena as barometric fluctuations and seismic disturbances, such as occurred in connection with the mighty eruption of Krakatoa.

The Mont Pelée cataclysm, as has been said, left no record on a seismograph. The disturbances noted on magnetographs were hence not to be ascribed to mere mechanical vibrations, but were distinctly of a magnetic character. The magnetic needle, instead of oscillating about the mean position, performed distinct, asymmetrical excursions.

In this connection it is interesting to note that numerous earthquakes that have occurred in this country during the past two years left no record on the established seismographs, but were recorded on the magnetographs of the United States Coast and Geodetic Survey. Many distant earthquakes have also left records on both seismographs and magnetographs. Valuable material is thus being collected for a study of the relation between seismic and magnetic phenomena.

Shortly after the magnetic disturbances were noticed at the magnetic observatories in this country and confirmed by the reports of some foreign observatories, a circular calling for data was sent by the Superintendent of the Coast and Geodetic Survey to all institutions engaged in magnetic work, and replies have been received from twenty-six observatories encircling the globe. The data called for embraced the days April 9 to 12, a similar disturbance to that of May 8 having occurred on April 10; April 17 to 19, covering the period of the Guatemalan earthquake, and finally for May 7 to 10. This circular had been sent out before the second remarkable coincidence of a magtic disturbance with an eruption of Mont Pelée, viz, that on May 20, 1902, had become known.

The entire material collected has been turned over to the recently formed department of international research in terrestrial magnetism of the Carnegie Institution of Washington for discussion and publication in detail.

It has been found that the times of the beginning of the magnetic disturbance on May 8, whether resulting from the curves of changes in magnetic declination, horizontal intensity, or vertical intensity, were practically the same over the entire globe; the differences in time were on the order of the error of the determination. The mean of the times of beginning derived from all the stations was $7^h\ 54^m.1$ a. m., St. Pierre local mean time. According to Heilprin the hands of the clock on the Hôpital Militaire at St. Pierre were found stopped at $7^h\ 52^m$ a. m.[a]

Until the mathematical analysis has been completed no definite statement can be made as to any casual connection between the eruption of May 8 and the remarkably coincident magnetic disturbance.

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[a] Heilprin, Angelo, Mont Pelée and the Tragedy of Martinique. Philadelphia and London, 1903, p. 329.

MAGNETIC STORMS AT CHELTENHAM MAGNETIC OBSERVATORY FROM AUGUST 1, 1903, TO AUGUST 31, 1904

By W. F. WALLIS
Magnetic observer in charge of Cheltenham Magnetic Observatory

As we approach the time of maximum sun-spot frequency a very noticeable increase in the number and violence of magnetic storms is observed. The Coast and Geodetic Survey magnetic observatory at Cheltenham has now been in operation for three years and a half, and of this period the last twelve months have been by far the most notable for magnetic disturbances. Indeed, it may be said that during the year there has been scarcely a day in which the suspended magnets have been permitted to pursue their normal daily courses unaffected by the mysterious disturbing influences.

A magnetic storm is indicated by rapid changes in the earth's magnetic elements. Or, to speak more concretely, if we consider the lines of magnetic force surrounding and penetrating the earth, we may think of a magnetic storm as a rolling and tossing of these lines, after the manner of the waves on a tempestuous sea. And the analogy does not end here. For as the oceanic waves have a more or less rhythmic motion, so the motions of the magnetic needle during a magnetic storm frequently exhibit a marked periodicity. Some magnetic storms have been characterized by long, slow oscillations having a period of two or three hours; and upon these larger oscillations are superimposed smaller ones; and upon these again innumerable small fluctuations. Some disturbances exhibit simple harmonic motions that may continue for an hour or more.

There is a great variety in the behavior of magnetic storms. Some last but a few hours, but may attain great violence in that time. Others may continue for days. Some begin with sudden violence; others gradually work up to a state of great agitation, then gradually calm down again.

In the following tabulation of the principal magnetic storms recorded at Cheltenham, an idea of the magnitude of the disturbance in each case is afforded by giving the range in declination, horizontal inten-

sity, and vertical intensity, and then the comparison with the corresponding monthly means of the daily ranges. In deriving the monthly means the days accompanied by magnetic storms were excluded. The times refer to Greenwich mean civil time, Cheltenham being 5^h $7^m.3$ west of Greenwich; the hours are numbered continuously from midnight to midnight, 0 to 24 hours. The unit used in expressing changes in intensity is 10^{-5} C. G. S.

Principal magnetic disturbances, August 1, 1903, to August 31, 1904.

No.	Year.	Approximate time of—			Total change in—			Approximate number of times, total change greater than—		
		Beginning.	Ending.	Greatest agitation.	Declination.	Horizontal intensity.	Vertical intensity.	Declination.	Horizontal intensity.	Vertical intensity.
					′					
1	1903	Aug. 21, 21^h	Aug. 22, 17^h	Aug. 22, 5^h	38.3	120	151	3.0	2.0	6.4
2	1903	Sept. 19, 4^h	Sept. 20, 17^h	Sept. 20, 0^h to 5^h.	38.8	115	45	3.5	2.0	2.0
3	1903	Oct. 11, 3^h	Oct. 14, 17^h	Oct. 13, 0^h to 5^h.	53.8	168	189	5.7	3.4	9.6
4	1903	Oct. 30, 22^h	(a)	Oct. 31, 4^h to Nov. 1, 16^h.	97.1	518+	161+	10.5	(?)	(?)
5	1903	Dec. 13, $12\frac{1}{2}^h$	Dec. 14, 6^h		24.8	130	150+	3.0	3.0	10+
6	1904	Mar. 31	Apr. 1		25.9	162	124	2.4	3.5	6.0
7	1904	May 11, 22^h	May 15, 5^h		25.0	178	159	2.3	4.0	6.3
8	1904	May 27, 17^h	May 29, 8^h		24.4	126	88	2.3	2.8	3.5
9	1904	June 4, 22^h	June 5, 4^h		3.0	73	7	1.4	1.4	1.4
10	1904	June 6, $4\frac{3}{4}^h$	June 7, 14^h		16.6	80	33	1.4	1.5	1.3
11	1904	June 15, 12^h	June 18, 5^h		40.9	241	199	3.4	4.5	7.8
12	1904	June 26, 14^h	June 28, 5^h		14.7	83	60	1.2	1.6	2.3
13	1904	July 1, 12^h	July 2, 2^h		17.7	80	24	1.5	1.4	1.0
14	1904	July 6, 7^h	July 10, 5^h		14.6	127	106	1.2	2.2	4.3
15	1904	July 13, 9^h	July 15, 9^h		14.8	78	38	1.2	1.3	1.5
16	1904	Aug. 1, 24^h	Aug. 5, 7^h	Aug. 2, 0^h to 8^h, and Aug. 3, 13^h to Aug. 4, 5^h.	21.3	125	62	1.4	2.0	2.4

[a] Lasted about a week.

Of this list, as will be seen, No. 4 is by far the largest disturbance. This is the great magnetic storm of October 31, which was accompanied by sun spots, auroral displays, and complete paralysis of telegraph and cable lines for several hours. The total changes in the horizontal intensity and vertical intensity are not known, as the horizontal-intensity minimum was beyond the limit of the recording apparatus, and the two vertical-intensity instruments were thrown out of balance by the violence of the disturbance. The part of the total change in the horizontal intensity actually recorded was at least one thirty-ninth part of the value of the horizontal intensity, and it would appear as though the total change may have amounted to as much as one twenty-sixth part of H. The amount of change measured in the vertical intensity before the instrument was put out of adjustment was at least 0.0016 C. G. S. unit, or about one two hundred and eighty-sixth part of the vertical intensity. The effect of this storm was to diminish the value of horizontal intensity below its normal value for about two weeks. A full report, accompanied by a reproduction of the magneto-

grams, was published by Dr. Bauer in the Journal of Terrestrial Magnetism and Atmospheric Electricity for March, 1904. This may be the most remarkable magnetic storm on record.

Nos. 3 and 11 rank next in magnitude.

No. 5 began suddenly at 12^h 29^m December 13, No. 9 suddenly at 22^h 38^m June 4, and No. 10 suddenly at 4^h 45^m June 6. In this case the total change in the vertical intensity was also not measured, as the trace passed off the sheet.

During the year the mean daily range in declination varied from 8′.4 in February to 14′.9 in August, in horizontal intensity from 43 in February to 68 in August, and in vertical intensity from 17 in February to 26 10^{-5} C. G. S. units in August.

In this list of magnetic storms the purpose has been to include only those disturbances that might properly be classed as among the more noteworthy ones. During the year there have been many slightly smaller disturbances that might almost have been included, and at times it has been hard to determine just where to draw the dividing line.

No mention has likewise been made of a large number of most interesting records obtained on the magnetographs due to seismic disturbances.

DISCUSSION

Dr. Bauer suggested that it would be extremely desirable to learn the experiences encountered during the recent magnetic storms at the Toronto magnetic observatory under Professor Stupart's charge. Owing to the fact that the Toronto and the Sitka magnetic observatories were practically on the same magnetic parallel, the former, however, being east and the latter west of the meridian passing through the magnetic pole, a careful comparison and analysis of the data of these two observatories respecting magnetic disturbances will doubtless be fruitful of highly valuable results.

THE HYDROGRAPHIC METHODS USED IN INTERNATIONAL COOPERATIVE STUDY OF THE SEA

By MARTIN KNUDSEN

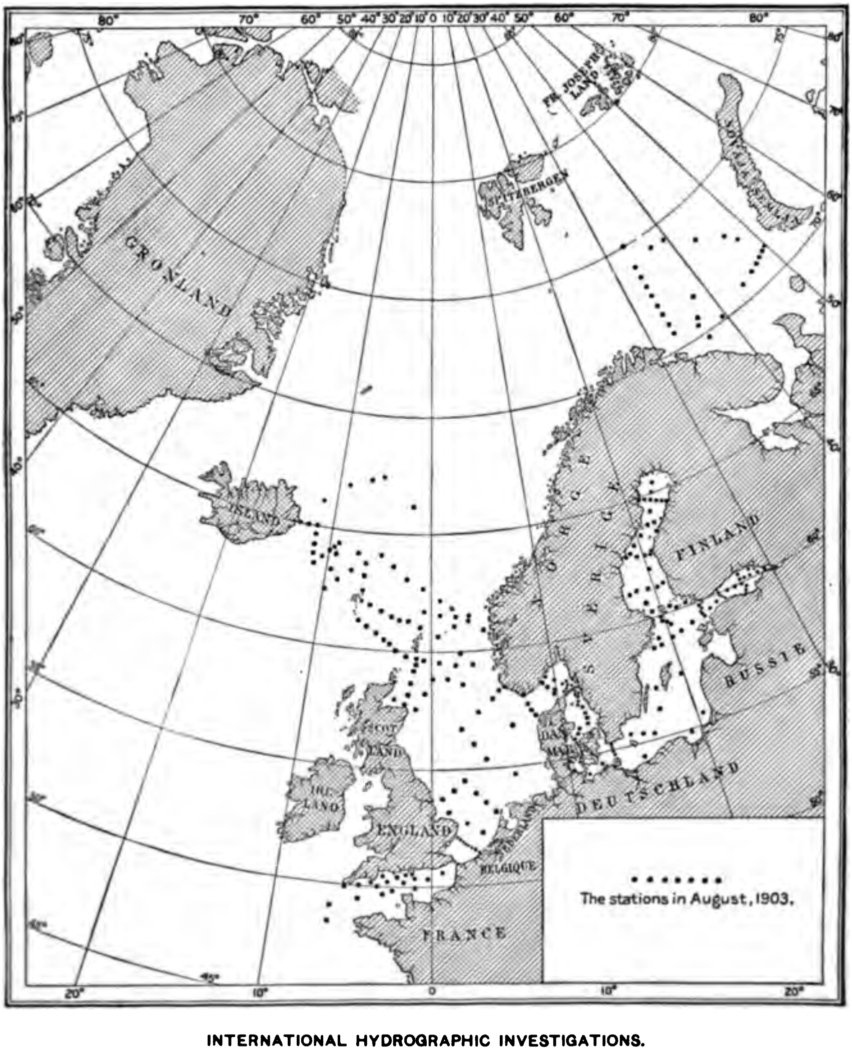
In August, 1902, Denmark, England, Finland, Germany, Holland, Norway, Russia, and Sweden began cooperative investigations of the sea. Later on Belgium joined, so nine of the north European countries are now exploring the north European seas; that is to say, the Baltic, Cattegat, Skagerak, the North Sea, the English Channel, the Norwegian Sea, and the northeastern part of the Atlantic. The investigations made are partly fishery investigations and partly hydrographic (or oceanographic) work.

The main object of these investigations has been to find the general hydrographic situation in all the seas; that is, to get information about the direction and extension of the currents and about the distribution of temperatures and salinities in the seas. The problem that has been attacked by the international hydrographic work is in the first place the variation from time to time in the hydrography of the different seas examined. In order to get knowledge about the changes which are going on from one season to another a certain series of observations is repeated four times a year, viz, in February, May, August, and November. During these months each of the cooperating countries sends one or two investigation steamers to the area which is to be investigated by the country in question, and thus all those ships take the observations as far as possible simultaneously.

The observations which are carried out during the seasonal cruises consist for the most essential part of temperature and salinity observations at certain places (stations) in different depths. The stations which have been chosen for examination are shown on the map.

The depths in which observations are taken are the following: 0 meter (the surface), 5, 10, 15, 20, 30, 40, 50, 75, 100, 150, 200, 250, 300, 400 meters, and so on, and the critical parts of the temperature and salinity curves are determined by extra readings.

The temperatures below the surface are measured either by means of a reversing thermometer or by means of the Petterson-Nansen insulating water bottle furnished with a thermometer.



INTERNATIONAL HYDROGRAPHIC INVESTIGATIONS.

The same water bottle is used for collecting water samples. The salinities of the water samples are determined by chlorine titration, either on board the ships or in the hydrographic laboratories of the different countries. The titrations are executed with a solution of silver nitrate, chromate of potassium being used as indicator, and by the titrations all the samples are compared with a single one, the standard water, in which the chlorine has been determined very carefully by more exact methods. The standard water is now procured by the central laboratory in Christiania.

All the observations of temperatures and salinities from the quarterly cruises are published in a bulletin by the central bureau in Copenhagen.[a] The bureau also publishes sections showing the distribution of temperatures and salinites in the sea, and from these sections conclusions may be drawn as to the direction and velocity of the different currents and also as to the changes which these currents undergo. As will be seen from the map, no stations are taken in the open Atlantic between Europe and America, and such stations are greatly wanted in order to understand many of the hydrographic changes that are going on in the waters under investigation. It is a pity that the cooperating countries have not been able to extend their seasonal cruises to the Atlantic, and it is to be hoped that America will some day join the work and fill up the gap in the European investigations.

As already mentioned, the essential part of the hydrographic work done at the stations consists in making observations of temperature and salinity, but many other observations are also undertaken; for instance, meteorological observations, viz, the direction and force of the wind, the temperature, pressure, and humidity of the air. On many occasions the direction and velocity of the current is observed at different depths by means of special current meters, and water samples are taken for determinations of the amount of carbonic acid, organic matter, nitrates, nitrites, phosphates, etc., and samples are also taken for determination of the absorbed amount of oxygen and nitrogen. Plankton samples are fished with different apparatus.

In order to avoid leaving completely out of sight such hydrographic changes as may go on and be entirely accomplished in the time between the seasonal cruises, hydrographic observations are also carried on by means of light vessels and steamship lines. Almost all the light vessels are lying in the neighborhood of the coast, in shallow water, and the observations there can give information only about the superficial layers; but on the other hand they can be taken very frequently. From the trading and mail steamers, which are crossing the sea in all directions, very useful material is collected, but only from the surface

[a] Bulletin des résultats acquis pendant les courses périodiques, publié par le Bureau du conseil. En commission chez Andr. Fred. Höst et fils, Copenhague.

itself, of course. The material thus procured consists again, in the first place, of temperature observations and water samples, which are sent to the various hydrographical laboratories for titration. The usual meteorological observations are also undertaken, and at some places plankton samples are fished for further determination.

In the hydrographic laboratories in the different countries the results of the observations are worked out, and such laboratory work is done as may have a direct bearing upon hydrographic questions.

The temperatures and salinities are mainly used as marks or criteria of the different kinds of water. For the deeper layers this can be done with full right, because neither the temperature nor the salinity can change its value at a certain distance below the surface unless new water comes in.

From the temperature and salinity the density of the water may also be deduced with sufficient exactitude for the calculation of the hydrodynamic forces arising from the differences in the values of the density.

It has been my object to set forth the methods of the international hydrographic investigations. As to the results arrived at by these investigations the reader is referred to the publications of the international bureau and of the institutions and laboratories in the different countries working in the matter.

HYDROLOGIC WORK OF THE U. S. GEOLOGICAL SURVEY IN THE EASTERN UNITED STATES

By MYRON L. FULLER, Chief Eastern Section, Division of Hydrology

ORGANIZATION OF THE DIVISION OF HYDROLOGY

The division of hydrology, or hydrogeology, as it might be more aptly termed, is that division of the U. S. Geological Survey which deals with underground waters in the same manner that the division of hydrography of the Survey deals with surface waters. It was organized on January 1, 1903, as a result of the increasing demand for information regarding underground waters, occasional investigations relating to which had previously been carried on incidentally to the studies of surface waters. The division was divided into two sections—eastern and western—the first embracing the 31 States east of the Mississippi River or bordering that river on the west, and the second including the remaining States and Territories. The two sections were placed in charge of geologists, Mr. M. L. Fuller being assigned to the eastern section and Mr. N. H. Darton to the western. Work was immediately organized in about two-thirds of the States and Territories, and a number of strictly scientific investigations were begun. The present account is based more especially on the work of the section in charge of the writer, but in its general nature that of the western section is not materially different.

WORK OF THE DIVISION OF HYDROLOGY

GENERAL SCOPE

The work of the Survey in hydrology may be grouped under six heads: (1) Bibliographic, (2) statistical, (3) technical, (4) legal, (5) scientific, and (6) economic.

It is only in certain of the scientific and economic lines that the work has a very definite relation to geography, but the account would be incomplete without at least a brief summary of the other lines of work.

(1) *Bibliographic work.*—No complete bibliography of underground waters in the United States has ever been prepared. To supply this

deficiency the preparation of the following reports was undertaken: (*a*) Bibliographic review of the numerous publications of the Survey with their many incidental references to underground water; (*b*) bibliography and index to all papers relating to underground waters published in the United States.

These are now in process of preparation and will be followed, it is expected, by a bibliography of European literature in so far as it relates to general problems of underground waters.

(2) *Statistical work.*—This consists of the collection and publication of data relating to wells and springs, a report on which has just appeared. In the case of wells the location, owner, diameter, depth, depth to water supply, material in which water occurs, height to which water rises, temperature, supply, quality, uses, etc., and, where possible, elevation above sea level are given. For springs the data include temperature, quality, volume, material from which spring issues, uses, and miscellaneous information.

(3) *Technical.*—The technical publications so far issued by the Survey include discussions of the types and economy of various classes of pumps used for raising underground waters and methods of sinking wells. It is proposed in the near future to prepare detailed reports on the various drilling methods and their applicability under different conditions.

(4) *Legal.*—A compilation of the laws relating to underground water is under way, the aim being to present in a simple manner, for the information of well owners and others interested in underground waters, a statement of their rights and obligations in the use of such waters.

(5) *Scientific work.*—Only mere mention of some of the problems under investigation will be made here.

(*a*) Measurement of direction and rate of underflow by electrical apparatus.

(*b*) Experimental field investigations of the general movements of ground water.

(*c*) Relations of ore and spring horizons.

(*d*) Relations of topography to underground drainage in regions of soluble rocks.

(*e*) Tidal, thermal, and barometric fluctuations of wells.

(*f*) Geology of underground waters, including mapping, stratigraphy, and collection of well samples.

(6) *Economic work.*—The economic work includes the preparation of reports and maps dealing with: (*a*) The location and extent of water-bearing horizons, (*b*) the depth of water below the surface, (*c*) the height to which it will rise, (*d*) the quantity to be obtained, (*e*) the quality of the supplies, (*f*) the uses to which the water is put, and (*g*) problems relating to pollution of ground waters, etc.

WORK RELATED TO GEOGRAPHY

Hydrology is most closely related to geography in the domain of topography although its relations are more or less intimate with several other of the many branches of geographic science, especially climatology. In many parts of the arid West climate is of predominating importance, but in the East there is everywhere sufficient rainfall to furnish an adequate source of underground water if the rocks have the necessary textural and structural features. The relation of the supplies of shallow wells to rainfall, however, is close even in the East.

Determination of the position and form of the water table and the direction of movement of the ground-water body.—The form of the water table depends upon a variety of factors, among which may be mentioned rainfall, texture of the water-bearing materials, nature of material underlying the upper water-bearing formation, and nature of adjacent land surfaces. It is the latter—in other words the topography —which, broadly speaking, ultimately determines the main features of the surface of the water table, for with a land surface without relief the tendency would be for the ground water to accumulate with a level upper surface, the variations from it being relatively unimportant and due to differences in texture and a consequent variability in capillarity and in resistance to the free passage of the water in its effort to seek the general level. Not only is the general form of the water table dependent on topography, but the motion of the ground water, its direction and velocity, are likewise determined by it. It is from the upper portion of the ground-water body, or near the water table, that the greater number of shallow wells derive their supplies, hence their relation to topography is especially intimate.

In many areas where the features of relief possess considerable magnitude, especially in regions where the topographic development has reached maturity and the whole surface is trenched by drainage channels, the details of level of the water table can be worked out with reasonable accuracy from an examination of the topography in connection with the zones of flow or leakage as marked by general seepage or springs. In less maturely developed regions, where the interstream areas are large, or in areas characterized by the flatness or peneplain characters of extreme old age it is only by means of wells, borings, etc., that the details of the water table can be worked out satisfactorily.

In both cases a thorough knowledge of the topography is essential. In the completely dissected areas it is necessary, in addition to knowing the rainfall and character of the rocks, to know the courses of the streams, the profiles of their beds, the extent of the interstream areas, and the form and elevation of the divides.

This knowledge is best supplied to the hydrologist by accurate contour maps. These maps are prepared by another branch of the Survey—the topographic—and are usually on a scale of 1 or 2 miles to the inch, including one-sixteenth or one-fourth of a square degree of surface, respectively. It is not proposed to go into the detail of the construction of these maps, but it may be said that they are controlled primarily by triangulation and precise levels. Many subordinate lines of levels are then run, the roads and topography being finally sketched in by a specially devised and very effective plane-table method. These maps are now made so accurately that it is usually possible to plot data relating to wells and underground waters with sufficient exactness for all ordinary purposes without further instrumental work. In a few cases, however, where the contour interval is large or where special accuracy is desired lines of spirit levels are run between the different wells and to localities in regard to which it may seem desirable to obtain exact information.

Mapping of catchment areas.—One of the first questions which arises in an untested artesian basin is whether the catchment area of the aquifer is of sufficient extent to collect an adequate supply of water. The solution of the problem necessitates both topographic and geologic surveys, the former to determine the limits of the area, the slope of its surface, and the character of its drainage, and the latter to determine the character, structure, and relations of the rocks. Climatology enters into the determination of rainfall and evaporation and hydrography into the measurement of run-off. The topographic surveys, as in the cases mentioned in the preceding paragraph, are commonly in the nature of surveys for topographic base maps, supplemented by additional lines of spirit levels where necessary.

Determination of geologic structure.—The competency of the catchment area to provide the aquifer with adequate supplies of water having been established, the extent, character, and depth of the water-bearing bed must be determined. The extent and character of the bed can sometimes be predicted in synclinal basins from the outcrops on either side, while its depth can be worked out from surface observations on the structure of overlying rocks. In more accurate work, however, further information, such as that afforded by wells and borings, is necessary, and to properly correlate the data the positions of the wells must be accurately fixed and their relative elevations determined. Here again topographic methods and topographic maps are demanded.

Determination of depth to water horizons.—This important information is obtained, wherever possible, by direct measurement of the depth to the water-bearing bed by steel tape, but as it seldom happens that a hydrologist is present when the well is drilling, the word of the driller or owner must usually be accepted. In many of the more

important wells the drillers themselves have used steel tapes, though cable measurements are more common. In order to compare the conditions at different points and to determine the conditions in untested areas, the wells and underground data are plotted on contour maps. When no contour maps are available, or when the contour interval is large, the wells are connected by levels. In the former instance the distance and bearing of the wells in relation to one another are also determined and sketch maps prepared.

Determination of head.—The head, or height to which the water will rise, is determined by measurement as in the case of the depth of the aquifers. When the well is in use or closed the word of the driller or owner is accepted, but whenever access to the well is possible the steel tape is used, the tape in this case being attached at the bottom to a wooden or metal float. Where there are fluctuations of level, recording gages are sometimes used. The wells and figures indicating the heads are plotted on contour maps as before.

In estimating the head in unexplored regions or where no well data are available, surveys are conducted to determine the level of the surface with reference to that of the catchment area of the supposed aquifer. When the elevation of the latter is known, together with the level of the zone of flow or leakage from the aquifer (which is similarly determined), a fairly close prediction can be made as to the height to which the water will rise, providing proper allowance is made for the loss of head due to the friction of the water in passing through the rocks.

Outlining of artesian areas.—With the head known and plotted on contour maps it is an easy matter to outline the areas in which waters may be expected to flow. In determining the limits of these areas in regions not covered by such maps the spirit level comes into important use. The value of such level lines is most manifest in flat areas underlain by very gently inclined water-bearing beds, such as the Atlantic and Gulf coastal plain regions, where over considerable areas a difference in elevation of a few feet, frequently less than 10, often determines whether a region will or will not yield flowing waters.

Cartographic representation.—In the final presentation of the data relating to underground waters in published reports topographic maps are again used. The use of these is best illustrated by the geologic folios issued by the Survey. In addition to the text, the folios include topographic, geologic, and economic maps, usually on a scale of 1 or 2 miles to an inch, and covering one-sixteenth or one-fourth of a square degree of the earth's surface, respectively. In them the underground waters receive the same treatment as other mineral substances, and wherever their importance warrants, a separate sheet is given for the representation of data relating to them. The information generally

shown includes: (1) Areas yielding flowing wells; (2) areas yielding pumping wells; (3) barren areas, and (4) contours of upper or lower surface of water-bearing beds. In the Pueblo (Colo.) folio, No. 36, which is a good illustration of the type of map under discussion, the flowing areas are represented in blue, the pumping areas in green, the barren areas in brown, and the depths of the water sands by contours in olive-gray. The coloration in the different areas varies in intensity, the portions yielding more copious supplies, or those rising to the greatest height, being darkest.

From these maps the owners of property and drillers are enabled to estimate their chances for obtaining water, to determine whether it will be flowing or nonflowing, and by subtracting the elevation of the aquifer from that of the surface contours at a given point, can foretell the depth to the water-bearing bed.

Summary.—In closing, it may be said that hydrology is indebted to geography, or more properly to that branch of geology known as topography, for a considerable part of its knowledge of the form and depth of the ground-water table and the direction of movement of the ground-water body. It is through topographic methods, especially the running of levels and the preparation of contour maps, that the areas of catchment basins are learned, their elevations with relation to the zone of flow or leakage from the aquifers and to the intervening areas determined, the amounts and directions of dips of the water-bearing beds calculated, the dips of the water horizons ascertained, the heights to which the water will rise fixed, and the productive areas outlined. Finally, it is on topographic maps and by topographic methods of expression, namely, by underground contours, that the results of ground-water surveys are largely presented.

HYDROGRAPHIC WORK OF THE U. S. GEOLOGICAL SURVEY

By GEO. B. HOLLISTER, U. S. Geological Survey

The flowing waters of the United States are among the country's richest and most important resources. The municipality, the manufacturer, and the irrigator all find them indispensable to the development of their enterprises, and yet until recent years but little reliable information regarding them was available.

The systematic study of the country's water resources by the United States Geological Survey began fourteen or fifteen years ago in the Western States and Territories in connection with surveys which were then carried on of reservoir sites for irrigation purposes. From this beginning the work has gradually expanded until it now includes in its field the whole territory of the United States, and has so increased its operations that at the present time approximately 600 gaging stations are maintained for the determination of stream discharge, and practically all the important rivers of the country are under investigation. In addition to simple stream measurements the activities of the division of hydrography also include the study of underground waters and the determination of the quality of water in different sections of the territory under consideration.

Broadly speaking, the hydrographic investigations of the Geological Survey may be summarized under the following heads: First, the determination of quantity, including the study of underground waters; second, the determination of quality of water; third, publications. A fourth section may be listed to describe the operations of the Reclamation Service, which is carrying on the development of irrigation enterprises under the irrigation act passed by Congress on June 17, 1902. Although this work, large in extent and of great importance in the development of the country, has, by Congressional enactment, been intrusted to the hydrographic branch of the Geological Survey, it is, strictly speaking, rather engineering than hydrographic in character, except in so far as it involves the study of the supply of many watersheds in the arid regions, which is a necessary preliminary to the building of extensive irrigation works.

interest, as they affect the progress of the country's development along many lines peculiar to its several portions.

In New England the work of stream measurements has been devoted to discovering the fullest possible development for power purposes. In Maine the development of power is complicated by the interests of the lumbermen, who require large quantities of water in the spring to run the logs cut during the winter to their sawmills, often at considerable distances. A study of power possibilities naturally extends over the entire Appalachian section, where the broad regional uplift and numerous areas of rugged topography afford considerable fall to the streams and many opportunities for power development. In the Southern States the use of water power has lately become exceedingly important. All along the Allegheny uplift streams fed by copious precipitation flow to the Atlantic Ocean on the one hand and to the Ohio and Mississippi rivers and the Gulf of Mexico on the other. In so doing they cross the mining regions of Georgia and Alabama and the extensive and fertile agricultural zones of North Carolina, South Carolina, Kentucky, Tennessee, and the Gulf States. There has been a great awakening of industry in the South, and the use of water power unquestionably is destined to play an important part in its further development. In this connection an interesting and fortunate circumstance may be noted, namely, that in their course from the mountains eastward to the sea, the rivers of this section pass over the relatively resistant crystalline rocks of the Piedmont Plateau in a series of falls and rapids, which are particularly noticeable at or near the dividing line between the Piedmont Plateau and the Coastal Plain. So certain is it to find important water powers on stream after stream from New England to Alabama, at or near the juncture of these geologic regions, that the distinctive term of the "fall line" has been used to describe it, and in consequence along this line, as has been frequently pointed out by geographers, are located a succession of towns and cities which have sprung up and flourish largely because of the existence of these water powers. Here and at other points on the Piedmont Plateau and Coastal Plains in the Southern States is found an important part of the cotton belt, and with the volume of flow of most of the streams that cross it, ideal conditions are found for power developments where power is most needed. Clearly such valuable resources as these power-bearing streams deserve the most careful consideration and study, and an important part of the work of the hydrographic branch of the Geological Survey is devoted to them.

In the southern New England, the Middle States, and the Central West the hydrographic problem is somewhat different. Though the water for power is still present, this is the area of thickly scattered towns and cities which must be furnished with adequate water supplies. Many of these communities are forced to take water for munici-

pal and domestic purposes from the surface streams, while others, though fewer in number, endeavor to supply their needs from underground sources. In certain sections of the country the population has become relatively congested, and the problem of a sufficient water supply is a serious one. This is particularly true of eastern Massachusetts, embracing the metropolitan district of Boston, where great expense has been incurred in making available, for municipal purposes, the waters of a number of comparatively small streams. The same problem is again met with in a striking manner in northern New Jersey, where, within a radius of 20 miles from the city of New York, are crowded, approximately, 500,000 people—one-third of the entire population of the State—who must be served with water from the neighboring streams of the region. None of these streams are large, and the supplies obtained from them will soon be taxed to the utmost capacity. Under such circumstances it is of vital importance that the run-off of all available watersheds should be accurately determined as the first step necessary for the solution of the problems concerning the securing of additional supplies as they may be needed. Greater New York, including the city of Brooklyn, with its 3,000,000 population, offers another instance where the stream-gaging work of the Geological Survey has been of assistance in furnishing data regarding the flow of streams which will soon be drawn upon as a source of supply.

In the West, as has been already intimated, the great value of the water supply, and that which is always uppermost, is its use in connection with irrigation. Without the use of water for cultivation vast areas of wonderfully fertile land would be uninhabited. With it the luxuriance, richness, and value of vegetation is surpassed nowhere in the country. Here the streams fed by meager precipitation, which comes mostly in the winter in the form of snow on the mountain ranges at their headwaters, flash out in great floods when the spring and summer sun melts the snow mantle, but quickly fall away to mere rivulets or dry up altogether in the crop-growing season, when their waters are most needed for cultivation. Here, where every cubic foot of water is of value, and where the total supply is sufficient for not one-tenth of the land which might be reclaimed, how important, nay, how absolutely necessary, is it to know without question the discharge of these priceless streams.

STUDY OF RELATIONS

Attention has been called to the results of stream gagings in their relation to the economic needs of the country, but they are also of great value as the basis for numerous investigations of a scientific nature—for example, the important question of the relation of rainfall to run-off, which differs so widely in various parts of the country; the

disputed questions of the relation of forests to run-off and the relations of forests to the occurrence of floods; the interesting question of storage due to the accumulation of snow, especially in the western mountain districts; the occurrence and character of floods in different parts of the country, and a number of other problems which require the fundamental discharge data for the determination. Again, much light is thrown by the gagings upon the striking differences of regional discharge between the flashy regimen of the eastern mountain streams under the influence of frequent and heavy storms which may produce flood conditions in any month of the year, and the behavior of the streams of the arid West which may be depended upon to swell to large proportions with the melting of the snows in the early spring and summer, and to dwindle to insignificance or dry up altogether during much of the remainder of the year. Geologic influences are also frequently discovered through stream measurements, as shown, for example, by the Dechutes River, which drains the lava plateau country of central Oregon. Here, owing to the storage of water in the sands and gravels alternating with the successive lava flows of the region, the volume of water flowing in this stream is kept remarkably uniform and shows very little alteration through different seasons of the year.

STUDY OF UNDERGROUND SUPPLY

Closely associated with the investigations into the volume of surface streams is the study of waters found beneath the surface. Within the last few years this has become such an important part of the hydrographic work of the Geological Survey as to warrant the formation of a separate division. Not only have careful records been made of wells in all parts of the country, but studies of the geologic conditions in regions where the existence of artesian basins is suspected are carried on so that all the facts upon which the currents of underground waters depend may be carefully considered. The results obtained from this work are perhaps more strikingly illustrated in investigations made in the northern portion of the Great Plains area, by which the geologists of the Survey have been able to locate the existence of an immense artesian basin underlying the Great Plains, fed by waters absorbed by the porous Dakota sandstone formation where it outcrops on the eastern flank of the Rocky Mountains and on the sides of the Black Hills uplift. As a result of these investigations, it is now possible to predict the approximate depth to which wells must be driven over large areas in North Dakota, South Dakota, and Nebraska to reach the water-bearing Dakota sandstones, and hydrographic maps of the entire region have been carefully prepared. In the East interesting investigations have also been carried on; for example, one to determine the occurrence of underground waters on Long Island, New

York, for use in connection with the water supply of the city of Brooklyn. Another investigation which is now in progress, and which is destined to be of the utmost importance, is the study of the direction and the rate of the flow of underground waters, particularly those through the gravels of dried-up streams. This is being accomplished by means of an ingenious electrical device. The details of this and other operations in the study of underground waters, which are being carried on by the Geological Survey, form the subject of another paper to be presented to this congress, hence no further mention is made of them at this time.

STUDY OF THE QUALITY OF WATER

As the investigation of water by the Geological Survey has developed, it has gradually grown to include not only stream gaging and the study of underground water conditions, but also investigations into the character of water in the different parts of the country. Thus far this investigation has been confined to preliminary studies of turbidity, hardness, alkalinity, the occurrence of normal chlorine, and the presence and amount of organic and inorganic pollution. This field, which has as yet hardly been entered upon, is wonderfully fascinating, presenting many problems of great importance. One of these is found in the region referred to in the Middle States and southern New England, where the population is most dense, and where the use of streams for sewage disposal is the common practice. Here are located also extensive manufacturing plants, and it is not idle curiosity to inquire what effects their effluents are producing in the streams.

In this region also occur the great anthracite coal fields, whose streams and small creeks run black with liquid mire, the washings from the culm piles. All over the United States run numerous railroad lines whose engines use enormous quantities of water. The power plants of manufacturing establishments as well, in every direction, must supply their boilers with water, and no one appreciates more clearly than the engineer how injurious are many waters in common use to boiler plants. In the arid West, where water is of great value for irrigation, there are streams containing such quantities of harmful salts in solution that their waters can not be used for agricultural purposes. It is of decided importance that a clear understanding of the quality of these waters be known. In a word, the discharges from bleacheries, cotton mills, manufactories of strawboard goods, sawmills, and a hundred other sources of pollution bring about a condition in the state of the country's water courses which demands the most careful study, and it is to throw light on these and kindred matters that the Geological Survey is studying the character of water.

PUBLICATIONS

The results of this work are published in the form of yearly progress reports which contain descriptions of gaging stations, records of gage heights, records of current meter and other measurements, and the maximum, minimum, and mean flow of streams upon which the stations are established, and other like data.

In addition to these annual reports there are published in a series known as the Water-Supply and Irrigation Papers separate reports of particular features of the work. These papers cover a wide field, embracing discussions of the water supply of irrigation districts, descriptions and measurements of noted floods, a manual showing the methods of stream measurements employed by the hydrographers of the Geological Survey, reports on normal or polluted waters in different sections of the country, reports on geologic work made to locate artesian basins, and papers on windmills and pumps and their relation to the water supply of the country. They also embrace reports in which are brought together all the available hydrographic information concerning particular States, such as one entitled "California Hydrography," and another called "The Water Resources of Colorado." In short, this series, which now contains over 100 volumes, aims, first, to present in concise form available for the use of engineers and water users the important facts about each stream under study and, second, to discuss the many different problems regarding which the Geological Survey through its hydrographic branch is attempting to obtain helpful information.

ZUR DYNAMIK DER SINKSTOFFE.

Von T. CHRISTEN, Oberförster, Bern, Switzerland

Eines der schwierigsten Probleme der Gewässerkunde ist die Erforschung aller derjenigen Faktoren, welche die Ausbildung eines Flussbettes bedingen. Die bezügliche Literatur weisst nach, dass nicht nur die Gesichtspunkte, unter welchen dieser Gegenstand beleuchtet werden kann, ausserordentlich viele sind, sondern auch, dass die meisten dieser Faktoren in vielfacher Combination einander bedingen. Wassermenge, Rauhigkeit der Flusssohle und der Einzugsgebiete, Gefälle, Grösse und Form des Querprofils, Grösse, Form, Menge und Anordnung des Geschiebes, Kolke und Fuhrten, Krümmungen und gerade Flussstrecken, alles das sind Verhältnisse, die einander gegenseitig bedingen, so dass die Veränderung des einen dieser Punkte auch die Veränderung sämmtlicher anderen zur Folge hat. In nachstehendem hofft sein Verfasser einen kleinen Beitrag zu der vorwürfigen Frage liefern und auf einige Gesichtspunkte hinweisen zu können, die zum Teil vielleicht noch zu wenig oder gar nicht gewürdigt werden.

Eine der wichtigsten Fragen, sowol vom Standpunkte der Hydrologie als namentlich auch von dem der Technik ist die: Wann befindet sich ein Gewässer im Gleichgewichtszustande? Als praktische Frage aufgefasst, können wir ihr antworten: Wenn sich sein Bett im Laufe der Zeit weder dauernd erhöht noch vertieft. Bekanntlich verursacht jede grössere Veränderung eines Flussbettes im Kulturlande Schaden. Ansammlung der Geschiebe erheischt Erhöhung der Seitendämme und songstigen Schutzbauten, Vertiefung der Sohle, und zieht dagegen Einsturz der Flussufer, Vermehrung der Geschiebe nach unten und Fortsetzung der Vertiefung nach oben mit sich. Einer der Hauptzielpunkte jeder Gewässerkonstruktion wird demnach die Herstellung eines Gleichgewichtszustandes sein. Aber wie schwierig ist diese Aufgabe! Während in einzelnen Flusspunkten vielleicht jahrelang kein grösseres Hochwasser aufgetreten ist, das Bett eines Kanals oder Flusses sich mittlerweile bedeutend erhöht hat und man der Versuchung nachgegeben, dem Flusse eine grössere Fläche Kulturland abzugewinnen, tritt einmal durch Zufall, z. B. durch Zusammentreffen

der Flutwellen verschiedener Zuflüsse, ein Hochwasser auf, welches die bisherigen an Intensität weit hinter sich lässt und die Dämme überflutet und beschädigt, oder es tritt eine Reihe von Jahren auf, wo die Erosion vorherrscht und sich das Flussbet wieder tiefer einbettet. Nur sorgfältige Beobachtung aller einschlägigen Faktoren während einer langen Reihe von Jahren kann da über ein wahrscheinliches Zuviel oder Zuwenig Aufschluss geben.

Wenn sonach von einem eigentlichen Gleichgewichtszustande eines Flusses nur in diesem Sinne gesprochen werden kann, so gibt es doch Phasen in der Ausgestaltung eines Gewässers, welche einem gewissen augenblicklichen Gleichgewichtszustande entsprechen.

An der Hand einer Darstellung der Vorgänge des Geschiebetransportes während verschiedener Wasserstände werden diese Verhältnisse wohl am klarsten vor Augen geführt.

Fangen wir an mit den Vorgängen während eines Hochwassers, das nach langer Pause der neptunischen Kräfte die Uferanwohner beunruhigt.

Mit der vergrösserten Wassermenge bringt der Strom auch bedeutend mehr Sinkstoffe. Zu Anfang sind letztere noch mit Schlick überzogen und reissen sich nur zögernd von der Unterlage los. Suchier,[a] welcher im Jahre 1874 sehr sorgfältige und eingehende Versuche über die Bewegung des Geschiebes am Oberrhein vorgenommen hatte, machte auf diesen Unterschied zwischen der Beweglichkeit beschlickter und rein gewaschener Geschiebe aufmerksam und schreibt ihn der festeren Lagerung und der verminderten Angriffsfläche der ersteren zu. Ich möchte noch auf eine weitere Ursache hinweisen, welche diese Erscheinung in ausgiebiger Weise beeinflusst. Wird nämlich der Schlamm um einen eingebetteten Stein entfernt, so kann das unter ihn dringende Wasser nicht mehr allseitig ausweichen wie an der oberen Seite des Geschiebestückes. Die Folge davon ist ein nach oben wirkender Seitendruck, welcher wohl gleich gesetzt werden kann einem Ausdruck von der Form $\varepsilon F \frac{v^2}{2g}$, wo ε für Ellipsoide nach Sternberg $=0.8$ beträgt und F die gestossene Lagerfläche des Steins bedeutet. Durch diesen dynamischen Auftrieb, welcher sich zu dem statischen addirt, erhebt er sich aus seiner Umgebung und wird von der Strömung fortgerissen. Damit ist das Hindernis, welches diesen Auftrieb verursachte, beseitigt, der Stein fällt zurück sobald seine nach aufwärts gerichtete Energie aufgezehrt ist.

Der Schlick wird nun allmälig vom Stromstrich aus gegen die Ufer hin abgewaschen, es beginnt das kleine, dann das grössere Material zu wandern. Immer tiefer greift diese Bewegung und wird nun der Schlamm auch in die höheren Schichten gehoben. Es beginnt der Massentransport. Die Hebung der feineren Bestandteile in höhere

[a] Die Bewegung der Geschiebe des Oberrheins. Deutsche Bauzeitung, 1883, No. 56.

Schichten ist nun in erster Linie abhängig von der Verteilung der Geschwindigkeit. An derjenigen Seite des schwimmenden Partikelchens wo die grössere Geschwindigkeit herrscht, findet grössere Ansaugung statt, so dass die hebende Kraft an den verschiedenen Stellen des Querprofils in engster Beziehung zum Differentialquotienten $\frac{du}{dh}$ steht, wo u die lokale Geschwindigkeit, h den Abstand von der Sohle bedeutet. Die Geschwindigkeitskurve wird nun selbst aber auch wieder von der ausgleichenden Wirkung der festen Bestandteile, d. h. von der erschwerten Verschiebung der beiderseitigen Wasserschichten beeinflusst, so dass zuletzt ein Augenblick eintritt, wo das Wasser kein neues Geschiebe mehr aufnehmen kann, ohne ein gleichwertiges Quantum wieder an die Sohle abzugeben. Die Gesammtmenge an Geschieben, welche der Fluss aufnehmen kann befindet sich am Sättigungspunkte, welcher natürlich für jeden Wasserstand verschieden ist. Das Gefälle welches diesem Zustande entspricht, nannte Breton[a] "Ausgleichsprofil" (profil de compensation), Surell,[b] "Grenzgefälle" (pente limite). Würden wir nach gesagtem die sogenannte Geschwindigkeitskurve kennen, sowie die Grösse der vorhandenen und zugeführten Geschiebe, so könnten wir näherungsweise die Vorgänge bei dieser Art der Verfrachtung der Sinkstoffe mathematisch verfolgen.

Diejenigen Steine, welche ihres Gewichtes halber der ansaugenden Wirkung der schneller bewegten Schichten widerstehen, werden nun entweder geschoben oder gerollt oder bleiben längere Zeit liegen. Das Rollen ist bei rundlichen Steinen die leichteste Fortbewegungsart. Eine Kugel rollt auf schiefer Ebene von selbst und sind ein Ellipsoid mit quergestellter Längsaxe oder eine Walze ebenfalls leicht zu rollen. Ganz schwere Geschiebe werden, wenn sie einigermassen rundlich sind, nur rollen. Gleiten werden hauptsächlich eckige Steine mit breiter Basis, welche aber doch der Strömung eine gehörige Stossfläche darbieten. Platten, welche solches nicht thun, werden hauptsächlich durch den dynamischen Auftrieb gehoben und dann leichter verfrachtet. Die Wahl der einen oder anderen Bewegungsart und die Lage der Geschiebestücke wird im Allgemeinen nach dem Prinzip des kleinsten Widerstandes stattfinden. Gerölle, d. h. rollende Sinkstoffe, werden sich so drehen, wie sie am leichtesten fortrollen können, was durch Querstellung ihrer Längsaxe geschieht. Geschiebe, d. h. geschobene Sinkstoffe legen sich dagegen so, dass sie der Strömung die geringstmögliche Stossfläche entgegenstellen, die längste Axe sich somit in die Richtung der Strömung stellt. Genaue Untersuchungen in verschiedenen Wildwassern haben dem Verfasser diese Ansichten bestätigt.

Die Hochfluten bringen das meiste Geschiebe, können es aber auch

[a] Breton, Mémoire sur les barrages de retenue des graviers dans les gorges des torrents. Paris, 1867.
[b] Alex. Surrell, Etude sur les torrents des Hautes Alpes. Paris, 1841.

am leichtesten verfrachten. Durch Ueberführung und stellenweise Abtragung wird die alte Verteilung von Fuhrten und Kolken teilweise unkenntlich gemacht, bleibt aber doch zum Teil, wenn auch mit gewissen Verschiebungen, bestehen. Beim Nachlassen des Hochwassers bleibt zuerst das grosse Geschiebe liegen, während das kleinere Material noch fortgeschwemmt wird und sich vorzugsweise an ruhigen Stellen unterhalb der Bänke und zwischen und über dem bereits abgelagerten grösseren Material ansetzt. Die Bänke bestehen infolge dessen auf der obern Seite aus gröberem Schutt und Kies, auf der der Strömung abgewendeten Seite aus Sand. Von diesen Bänken wird der Strom auf die andere Seite gedrängt, greift dort das Ufer an und verursacht die bekannten Kolke. In eigentlichen, durch schnell verlaufende Gewitterregen angeschwollenen Wildwassern und bei Murgängen kann sich wegen der Schnelligkeit der Abnahme der Hochflut diese Ausscheidung des Materials nicht ausbilden und bemerkt man höchstens etwa, dass die grossen Steine meist oben aufliegen, weil sie ihrer Grösse halber nur rollend vorwärts kommen und dabei über das kleinere Geschiebe hinaus gewalzt werden.

Vollständige Geschwindigkeitsmessungen an Gewässern während eigentlicher Hochfluten liegen sehr wenige vor, da solche der grossen Wassergewalt halber ausserordentlich erschwert werden. Nur Tiefenschwimmer-Methoden können auch da über die Schwierigkeiten hinweghelfen.

Ueberblicken wir die Gesammtwirkung eines Hochwassers auf den Grundriss des Flusslaufes, so hat es hauptsächlich eine ausgleichende Wirkung. Andererseits macht es das Bett rauher.

Niederwasser.—Sinkt nach Hochwasser der Wasserspiegel allmälig, so setzen sich nach und nach die Sinkstoffe nach der Ordnung ihrer Schwere zu Boden, den Thalweg auspflasternd, die kleinen Zwischenräume ausfüllend. Nach und nach bedecken sich die Geschiebe, den Thalweg ausgenommen, mit Schlick, so dass schliesslich die Fläche eine bedeutend geringere Rauhigkeit besitzt, als sur Zeit des Beginns der Niederwasserperiode. Werden bei reinem Wasser gar keine Geschiebe mehr transportirt, so haben wir den Fall des Gleichgewichtsprofils (profil d'équilibre) nach Breton.

Mittelwasser.—Steigt nach längere Zeit bestandenem Niederwasser der Wasserspiegel wieder zu mässiger Höhe, so kann das beschlickte Flussbett längere Zeit der grösseren Geschwindigkeit Stand halten, es überwiegt der Widerstand der Sohle die Schubkraft. Schliesslich aber kann durch länger anhaltendes Mittelwasser, wenn solches nur wenig Sinkstoffe bringt, die Sohle durch Wegführung des Schlammes nach und nach sehr rauh werden. In eigentlichen Wildwassern sind gerade solch häufig auftretende und längere Zeit andauernde mittlere Wasserstände oft die Hauptförderer der, Unterkolkungen der Seitenhänge une Schutzbauten.

Wollen wir nun zu einer summarischen Berechnung von Flussgeschwindigkeiten Formeln anwenden, so dürfen wir dabei nicht ausser Acht lassen, dass sich jede auf einen Rauhigkeits-Koeffizienten basierte Formel in erste Linie auf Versuche an unveränderlichen Wandungen stützt, dass also eine solche nur einem ganz bestimmten Sohlenzustande entsprechen kann und für alle anderen Zustände nicht mehr gilt. Wollen wir die Formel auch auf andere Zustände anwendbar machen, so müssen wir nach einer Beziehung zwischen dem Rauhigkeits-Koeffizienten und der veränderlichen Schubkraft suchen. Dabei ist est für solche Untersuchungen fast gleichgültig, nach welcher Geschwindigkeits-Formel man rechne. Müssen doch die Fehlergrenzen angesichts der enormen Unregelmässigkeiten und der Beweglichkeit der Flussläufe so weit genommen werden, dass dabei die etwas geringere oder grössere Genauigkeit der Formeln gar nicht in Betracht fällt. Man sollte meines Erachtens einmal zugeben, dass mit noch so genauen Geschwindigkeits-Messungen an natürlichen Wasserläufen eine einigermassen genaue Geschwindigkeitsformel nicht geprüft werden kann, sondern nur an ganz genau gearbeiteten und unveränderlichen Gerinnen. Wird doch bei solchen Messungen so zu sagen nie auf die fast stets herrschende ungleichförmige Bewegung Rücksicht genommen und ebensowenig das sehr häufig vorhandene Quergefälle berücksichtigt. Es würde den Rahmen und den Zweck dieses Aufsatzes weit überschreiten, wollte ich an der Hand einer grossen Zahl mir vorliegender Rechnungsergebnisse an ganz unregelmässigen Flussstrecken nachweisen, wie durch Berücksichtigung dieser Verhältnisse die Genauigkeit der Geschwindigkeitsformeln eine ganz andere, meist ganz befriedigende wird.

In meinem Buche: "Das Gesetz der Translation des Wassers in regelmässigen Kanälen, Flüssen und Röhren, Leipzig, 1903," habe ich durch eine eigene Versuchsanordnung der Bazin'schen Gerinne die dann an sämmtlichen mir bekannt gewordenen Geschwindigkeitsmessungen geprüfte Fundamentalformel aufgestellt: $v=\frac{k}{\sqrt[4]{B}}\sqrt[3]{QI}$ oder $v=m\sqrt{TI}\sqrt[4]{B}$, wo Q die Wassermenge, I das Gefälle, B die halbe Breite, T die mittlere Tiefe bedeuten. k und m sind innerhalb desselben Rauhigkeitsgrades Konstante, welche mit meist unbedeutenden Fehlern behaftet sind, deren Auftreten nur schwer eine Regelmässigkeit erkennen lässt und welche ich den doch noch ziemlich beträchtlichen Konstruktionsmängeln der betreffenden Gerinne, d. h. den infolge derselben auftretenden ungleichförmigen Bewegungen des Wassers zuschreibe.

Diese Formeln habe ich als ein Naturgesetz, d. h. als eine physikalische Beziehung dargestellt, nicht nur weil sie mit den Messungen an den offenen Kanälen und an Röhren durchaus befriedigend übereinstimmen, sondern weildie zweite in dem Ausdruck $\sqrt[4]{B}$ die Formel für

die Einzelgeschwindigkeiten enthält, welche für die einfachsten Verhältnisse, nämlich für die Geschwindigkeitskurven im Kreis und Halbkreis, für die Vertikalkurven des Stromstrichs sehr breiter und für die Oberflächenkurve sehr tiefer Kanäle sich mit einer Maximal-Differenz von wenigen Prozent oder gar Promille an die Parabel 8ter Ordnung, mit dem Scheitel an der Wandung, anschliesst, d. h. mit einer Genauigkeit, welche alle bisherigen Formeln für die Einzelgeschwindigkeiten, meist weit, übertrifft und in allen Fällen vollkommen befriedigt. Die übrigen Geschwindigkeitskurven, namentlich in natürlichen Flussläufen, sind dagegen komplizirter.

Die Grösse TI in obiger Formel, oder vollständiger im irdischen Meter- und Tonnen-System ausgedruckt: TI 8, wo 8 das Gewicht per Kubikeinheit Wasser bedeutet, ist nach Du Boys[a] die Schubkraft oder Schlagkraft (force d'entraînement), d. h. die tangentale Kraft der Reibung per m^2 Wasserspiegelfläche. Die Rauhigkeit selbst ist nun eine ziemlich komplexe Grösse. Sie wird vornehmlich bedingt durch die Grösse des oberflächlichen Materials des Flussbettes, von der Zahl und Grösse der daraus hervorragenden grössten Geschiebestücke und durch die Menge des schwimmend erhaltenen Materials. Da sich die Rauhigkeit der Sohle, d. h. der Geschwindigkeits-Koeffizient *m* hauptsächlich nach dieser Schubkraft richten muss, so habe ich mittelst der logarithmischen Methode an 114 ganz verschiedenen Flussgebieten und Wasserständen entnommenen Geschwindigkeitsmessungen untersucht, nach welcher Potenz von TI sich *m* verändert und dabei die Beziehung $m = \frac{6,3}{\sqrt[6]{TI}}$ gefunden, welche Formel in die Fundamentalformel eingesetzt die Gleichung giebt:

$$v = 6,3 \sqrt[3]{TI} \sqrt[8]{B} \text{ oder allgemein}$$

$$v = a \sqrt[3]{TI} \sqrt[8]{B}$$

Diese Formel prüfte ich an 204 Messresultaten und fand folgende Fehler:

Bei 66 Messungen oder 33 Prozent der Fälle stimmte die Formel bis auf 10 Prozent genau; bei 61 Messungen oder 29 Prozent der Fälle stimmte die Formel bis auf 20 Prozent genau; bei 44 Messungen oder 21 Prozent der Fälle stimmte die Formel bis auf 35 Prozent genau; bei 33 Messungen oder 17 Prozent der Fälle stimmte die Formel bis über 35 Prozent genau.

Durch eine nochmalige Berechnung von *a*, wodurch diese Grösse noch etwas grösser ausfallen würde, könnte die Formel noch besser zum Übereinstimmen gebracht werden. Da ausserdem unter den zur Ermittelung von *a* benutzten Messungen die meisten beim Niederwasserstande und wohl viele bei beginnendem Niederwasser gemacht wurden, so wäre der richtige Koeffizient *a* auch aus diesem Grunde

[a] P. Du Boys, Le Rhône et les rivières à lit affouillable. Annales Ponts et Chaussées, 1879, II.

etwas höher anzunehmen und etwa gleich 7 zu setzen. Denn es ist ohne weiteres klar, dass die Gleichung $v = a\sqrt[3]{TI}\,\sqrt{B}$ nur dann Geltung haben kann, wenn die Geschiebe Zeit gefunden haben, sich der herrschenden Schubkraft anzupassen. Aus diesem Grunde auch nannte ich diese Formel "Gleichgewichtsformel," weil sie die Geschwindigkeit nur unter dieser Voraussetzung des Gleichgewichts zwischen Schubkraft und Rauhigkeit richtig angeben kann.

In gestauten Flussläufen, wie oberhalb von Bänken und Krümmungen, noch in Strecken mit Absenkungen, kann die Grösse TI nicht als Mass der Schubkraft gelten, da bei Stauungen, z. B. das Wasser nicht durch die tangentalen Reibungskräfte, sondern auch durch die vor ihm liegenden Hindernisse aufgehalten wird. Hochwasser hat in gestauten Flussstrecken eine Abnahme, in abgesenkten eine Zunahme des Gefälls zur Folge, ohne dass die Verminderung oder Vergrösserung des Gefälls damit Schritt hält. Für die einzelnen Gewässerkategorien gelten folgende Durchschnitts-Werthe der Schubkraft. Ströme haben eine solche von ca. 90 gr., Flüsse und Bäche von etwa 260 gr., Wildbäche von ca. 2 kilogram. Im Allgemeinen muss gegen das Meer zu die Schubkraft abnehmen, indem gegen dasselbe hin die mittlere Tiefe nur wenig zu-, dagegen das Gefälle ganz gewaltig abnimmt. Während z. B. von Chur bis Holland die Tiefe des Rheins nur um das 4fache zunimmt, sinkt das Gefälle auf dieser Strecke um das 17fache. Ein Glück, dass sich die Geschiebe beim Transport abnutzen, sonst würde sich alles Material schon gleich beim Austritt aus dem Gebirge stauen. Ein Hauptaugenmerk bei Korrektionen muss darauf gerichtet sein, die Schubkraft TI8, d. h. die mittlere Tiefe, so zu wählen, dass der Fluss nicht nur seine eigenen, sondern auch noch die wegen meist grösserer Schubkraft und noch geringerer Abschleifung schwereren Geschiebe seiner Nebenflüsse zu transportiren vermag.

Stellen wir uns nun die wichtige Frage: Wann erhöht sich ein Flussbett, so lautet die Antwort einfach: Wenn im oberen Teil eines Flussabschnittes mehr Geschiebe zu- als im untern abströmt. Findet das umgekehrte statt, so besteht Abtragung, Erosion. Beides, Auftrag und Abtrag, kann bei jedem Wasserstande stattfinden, je nach den begleitenden Umständen.

Fassen wir das Gesagte kurz zusammen, können wir folgende Gleichgewichtszustände unterscheiden, von denen der erstere sich auf den Augenblick bezieht und lediglich bezüglich der sogenannten Rauhigkeit eine Rolle spielt, der zweite aber sich sowol auf den momentanen Zustand wie auch auf eine längere Reihe von Jahren beziehen kann und sowol das Kompensations- wie das Gleichgewichtsprofil nach Breton in sich begreift.

(1) Das Gleichgewicht zwischen Schubkraft und Geschiebewider-

stand, welches dann vorhanden ist, wenn die Geschiebe-Anordnung und der Transport der Geschiebe sich der Schubkraft angepasst haben. Dies ist nicht der Fall bei Beginn eines Hochwassers und einer Niederwasserperiode.

(2) Das Gleichgewicht gegenüber Erhöhung oder Abtragung. Dieses wird einzig bedingt durch den verschiedenen Gehalt an Geschieben im oberen und unteren Teil einer Strecke. Meist findet Auftrag statt, da die Schubkraft im Allgemeinen von oben nach unten abnimmt. Erosion kann nur da stattfinden, wo das herbeiströmende Wasser geschiebearm ist, wie unmittelbar unterhalb gut beraster oder bewaldeter Einzugsgebiete oder in solchen Flussstrecken wo bei gleichmässigem Gefälle die Breite ab- oder bei gleicher Breite das Gefälle zunimmt, sowie an aus Seen austretenden Gewässern und unterhalb grösserer geschiebearmer Zuflüsse.

Von diesen Gleichgewichtszuständen ausgehend, lassen sich die bei der Ausbildung eines Flussbettes stattfindenden Erscheinungen im Allgemeinen übersehen.

Ich schliesse mit dem Wunsche, es möchte gelegentlich der hydrometrischen Aufnahme mehr Aufmerksamkeit auf eine genaue Charakteristik der Geschiebe und auf die Kontrolle der ungleichförmigen und seitlichen Bewegung verwendet werden, letzteres durch zusammenhängende Aufnahme von wenigstens je 3 in passender Entfernung auf einander folgenden Querprofilen.

RECENT PRACTICE IN THE COAST AND GEODETIC SURVEY IN PRIMARY TRIANGULATION, BASE MEASUREMENT, AND PRECISE LEVELING

By JOHN F. HAYFORD, Inspector of Geodetic Work, U. S. Coast and Geodetic Survey

In three lines of surveying, namely, primary triangulation, base measurement, and precise leveling, the practice of the Coast and Geodetic Survey has changed rapidly during the last ten years. The changes made have been the logical result of the seven decades of accumulated experience of the Survey. During these seven decades there has been a wide diversity of practice on different parties, even between different parties engaged at the same time on the same kind of work, the policy of the Survey having been to leave to the chief of each field party the choice of methods and instruments, and even, to a considerable extent, the grade of accuracy to be secured. From a careful comparative study of the results of this diversity of practice it has been possible to select the best features of the various methods which have been used and to test the value of many suggestions which have been made as to desirable changes. The effect of the comparative study of results, and of the selection from among many existing methods and suggestions of those which should be retained and acted upon, has been a remarkable increase in the rapidity of the work, and a corresponding decrease in its cost, without any sacrifice of accuracy.

PRIMARY TRIANGULATION

A measure of the improvement in practice in the primary triangulation is afforded by the statement that the unit costs of this class of work during the last two years have been reduced from 25 to 50 per cent or more below their former values. The accuracy of this rapid triangulation of moderate cost has been carefully tested and found to be such as to place the triangulation with the more accurate half of all the primary triangulation which has been done in the United States.

A double observing party (2 observers), 21 persons in all, including light keepers and tower builders, extended the triangulation southward along the ninety-eighth meridian from Kansas to central Texas, a dis-

tance of 444 miles (715 kilometers), in less than eight months in 1902. Their average rate of progress was 55 miles (89 kilometers), per month, making no allowance for delays of any kind. The total number of stations occupied was 75.[a]

The number of observations of each angle taken in the recent primary triangulation was but 16; formerly 22 to 34 or even more measures were made. In recent work all of the observations at a station are sometimes secured in a single day, and are frequently secured in two observing days. Each observer usually completes from five to seven stations per month, including all moves between stations and other delays. In July, 1904, one observer made all the observations at ten primary stations in Minnesota. In earlier work an average of two stations per month for a whole season for an observer was considered a remarkably good record.

On the recent primary triangulation much of the observing has been done at night upon acetylene lamps; directions to the distant light keepers have been sent by the telegraph alphabet and flashes of light, and the necessary observing towers have been built by a party expert in that kind of work in advance of the observing party.

BASE MEASUREMENT

In 1891, on the Holton base in Indiana, the use of narrow steel tapes for primary base measurement in the United States was begun. The methods of tape measurement have been somewhat improved in the thirteen years since that time. The esteem in which the steel tape is held as a base apparatus has steadily increased as the facts have become evident as to the rapidity, cheapness, and accuracy with which measures can be made with it. The steel tapes here referred to are 6.3 millimeters (one-fourth inch) wide, 0.47 millimeters (one-fiftieth inch) thick, and 50 meters or 100 meters (164 or 328 feet) long.

During this same period the art of measuring bases with bars has been advanced by the development of an improved form of base bar, the duplex base apparatus.[b] This apparatus is unique in utilizing both the bimetallic and thermometric methods of determining the temperature of the measuring bars.

The latest primary base measurements in the Coast and Geodetic Survey were made in 1900[c] and showed a remarkable increase in rapidity and economy as compared with any former base measurements of a primary standard of accuracy. Formerly it had been the usual practice to organize a party for the measurement of a single

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[a] For a full account of the triangulation during this season see Appendix 4 of the Coast and Geodetic Survey Report for 1903.

[b] See The duplex base apparatus and The measurement of the Salt Lake base, Appendices 11 and 12 of the Coast and Geodetic Survey Report for 1897.

[c] See On the measurement of nine bases along the ninety-eighth meridian, Appendix 3 of the Coast and Geodetic Survey Report for 1901.

base. In 1900 a single party of 10 persons measured nine primary bases in six months. The skill and experience gained on each base enabled the party to work with increased ease and rapidity on each successive base.

The average length of the nine bases measured in 1900 was 4.8 miles (7.7 kilometers), and the average probable error of the length of a base was one part in 1,200,000. The total cost of the measurements, including salaries, transportation, and the office work at Washington, was $260 per mile ($160 per kilometer).

The duplex bar apparatus and four steel tapes were used on every base. About four-fifths of the measuring was done with tapes. The tapes and bars were standardized in the open air in the field under conditions as nearly as possible identical in all respects, and especially as to temperature, with the average conditions encountered in the base measurement, the purpose being to guard against constant errors.

The use of both bars and tapes by the same party afforded an unusual opportunity to compare them as to the cost and accuracy of the results. The cost per mile of measurement with tapes was found to be a little more than one-third as great as with bars. The accuracy obtained was substantially the same, the very slight difference being in favor of the bars.

Another advantage of the tapes over the bars is that with tapes the measurement may be made without any decrease in accuracy over rough ground and on any grade not exceeding 10 per cent.

PRECISE LEVELING

The improvement in the method and instruments[a] used in precise leveling is indicated by the fact that the leveling now done in the Coast and Geodetic Survey costs from $7 to $11 per completed mile, including all salaries and the cost of bench marks, whereas leveling of the same grade of accuracy by other organizations has cost from $14 to $24 per completed mile, or even more.

The new precise-leveling instrument designed, built, and put into use in the Coast and Geodetic Survey in 1900 is of the irreversible type. It is very compact in form, parts which should hold their relative positions unchanged being placed as near as possible to each other. Nickel-steel and nickel-iron alloys were extensively used to avoid movements due to temperature. The use of direct-reading rods, of a quick-leveling screw under the eye end of the telescope, and of a reading device which enables the observer to see both the rod and the bubble clearly at the same time, makes the observations very rapid as well as accurate. It is believed that this type of instrument is superior to the wye level for leveling of any order of accuracy.

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[a] See Precise leveling in the United States, 1900–1903, Appendix 3 of the Coast and Geodetic Survey Report for 1903.

On the first 2,400 miles of precise leveling done with thi- instrument, 1900–1902, the average rate of progress was 66 miles per month. Every completed mile represents a mil- least twice, once in the forward and once in the backwa- During the most rapid month of leveling 105 miles we- The number of miles of single line was 223, and the pr- miles of single line per working day. The average during this month was 83 meters (272 feet). The a- sight on the whole 2,400 miles is about the same as f-

The accuracy secured with this instrument is fu- formerly obtained in any precise leveling in the Un- adjustment of the precise-level net covering th- United States, the largest correction which it ha- to apply to any line run with the new instrume- per kilometer (0.00039 foot per mile), and on lines the necessary correction to close all ci- millimeters per kilometer (0.00010 foot per m-

In the precise-level net referred to[a] ther- kilometers) of leveling, of which about on- by the Coast and Geodetic Survey with the- with a former type of instrument, the C- levels, and the United States Lake Su- The remainder consists of miscellane- greater portion has been contributed b- The probable error of the derived ele- Louis is only ±3 centimeters (±1 in- furnishes a rigid control for all oth-

[a] See Appendix 3 of the Coast and

THE FORM OF THE GEOID AS DETERMINED BY MEASUREMENTS IN THE UNITED STATES

By JOHN F. HAYFORD, Inspector of Geodetic Work, U. S. Coast and Geodetic Survey

In this paper it is proposed to sketch broadly the plan of an investigation which is now in progress and is far from being complete, and to make a preliminary statement of some of the conclusions reached thus far. It is to the general method and the great scope of the investigation that it is desired especially to call the attention of this congress.

The contributions already made by the United States to the study of the figure of the earth include two great arcs, one spanning the continent along the thirty-ninth parallel, the other extending in an oblique direction from Maine to Louisiana. They also include several shorter arcs. Each of these arcs has been treated in the traditional manner as independent of each of the others, except that they are assumed to lie upon the same spheroid in certain latitudes.

In the investigation now in progress a widely different method is being followed. The two great arcs previously referred to, as well as the several shorter arcs and some new arcs not yet utilized, are all to be treated as a single unit by what may be called the area method as contrasted with the arc method. The arc method of deducing the figure of the earth may be illustrated by supposing that a skilled workman to whom is given several stiff wires, each representing a geodetic arc, either of a parallel or a meridian, each bent to the radius deduced from the astronomic observations of that arc, is told in what latitude each is located on the geoid and then requested to construct the ellipsoid of revolution which will conform most closely to the bent wires. Similarly, the area method is illustrated by supposing that the workman is given a piece of sheet metal cut to the outline of the continuous triangulation which is supplied with the necessary astronomic observations, and accurately molded to fit the curvature of the geoid, as shown by the astronomic observations, and that the workman is then requested to construct the ellipsoid of revolution which will conform most accurately to the bent sheet. Such a bent sheet

essentially includes within itself the bent wires referred to in the first illustration, and, moreover, the wires are now held rigidly in their proper relative positions. The sheet is much more, however, than this rigid system of bent lines, for each arc usually treated as a line is really a belt of considerable width which is now utilized fully. It is obvious that the workman would succeed much better in constructing accurately the required ellipsoid of revolution from the one bent sheet than from the several bent wires. When this proposition is examined analytically it will be seen to be true to a much greater extent than appears from this crude illustration.

The area of irregular shape which is being treated as a single unit extends from Maine to California and from Lake Superior to the Gulf of Mexico. It covers a range of 57° in longitude and 19° in latitude, and contains 477 astronomic stations. This triangulation with its numerous accompanying astronomic observations will, even without combination with similar work in other countries, furnish a remarkably strong determination of the figure and size of the earth.

No determination of the figure of the earth can be made without assuming implicitly either the truth or the falsity of the theory of isostasy.

If the investigation of the figure is based simply upon the observed deflections of the vertical, that is, upon the differences respectively between the astronomic and the geodetic latitude, astronomic and geodetic longitude, and the astronomic and geodetic azimuth, this is equivalent to assuming that the theory of isostasy is true even to the extreme extent of assuming that each mountain range and each separate hill or mountain is compensated for by a corresponding deficiency of density under that particular range, mountain, or hill, and that such deficiency occurs close to the surface. This is an extreme assumption which even the most enthusiastic advocate of the theory of isostasy is not likely to claim as true.

Under no other circumstances can it be true that the observed deflections of the vertical are independent of the topography. As a rule, the only way in which a concession is made, in determining the figure of the earth, to the idea that the observed deflections of the vertical are related to the topography is in rejecting certain observations made at stations in mountainous regions.

On the other hand, suppose the deflections to be computed which would be produced according to the law of gravity by all masses above sea level considered as excesses, and also the deflections corresponding to the negative masses below sea level represented by the depression of the ocean bottom. These computed deflections must exist at each station on account of the topography upon the hypothesis of extreme rigidity; in other words, upon the hypothesis that there is no truth in the theory of isostasy. If the figure of the earth is computed on the

assumption of extreme rigidity, the investigation must be based upon the observed deflections after these computed topographic deflections have been subtracted from them. When the investigation is attempted it at once becomes evident that the corrections for topography are not sufficiently complete unless the computation is extended over a radius of thousands of miles, not simply tens or hundreds of miles. Otherwise a considerable portion of the topographic deflection would have been neglected.

Evidence entirely outside this investigation indicates that the fact probably lies between these two extreme assumptions, of extreme rigidity, and of perfect isostasy with the compensation near to the surface. The isostatic compensation probably occurs only in a general way for large areas, not for separate mountains, and the compensation probably is not complete in the first few miles below the surface. The investigation in progress deals frankly and explicitly with the theory of isostasy as a necessary part of the investigation of the figure and size of the earth and attempts to determine the extent and manner in which the isostatic compensation occurs.

The first step in the investigation, forming a reconnoissance of the problem, was to construct graphically the contour lines of the geoid referred to the Clarke spheroid of 1866 as a reference surface. Each astronomic observation furnishes a measure of the slope of the geoid at the station of observation with reference to the Clarke spheroid of 1866 upon which the triangulation was computed. By a specially devised graphic process the contour lines of the geoid were constructed from these observed slopes and without any dependence upon anything else. The contour lines of the geoid were then compared with the topographic contour lines which show the relief of the continent. A correspondence was evident, as a rule, between the contour lines of the geoid and the general features of the topography which extend over large areas. For example, the contour lines of the geoid along the Atlantic coast follow the general trend of the coast. The conclusion from the comparison was that the deflections of the vertical are influenced by the excesses and defects of mass corresponding to the irregularities of the land surface existing for hundreds of miles around each station rather than the excesses and defects which exist within a short distance of the station, say 10 miles. This means that if the compensation required by the theory of isostasy exists, it is deep seated, extending for scores or hundreds of miles below the surface.

The second step of the investigation is to compute the topographic deflections upon the assumption of extreme rigidity, all masses above sea level being assumed to be excesses, and the ocean depths to represent defects of mass. As the study of the contour lines of the geoid had shown clearly that the computation must be extended for a long distance from each station, it was so made as to take into account the

topography within a circle of 4,126 kilometers (2,564 miles) around each station. To cover so large an area for each station required the development of special methods in order to reduce the time required for the computation within a feasible limit. The method used is the well-known one of dividing the area around each station into compartments by circles and radial lines so that the deflection at the station produced by the material in each compartment is proportional to the mean elevation of the land within that compartment. Two special devices were used to shorten the work. The compensation lines were superposed on the topographic maps by being drawn upon transparent celluloid sheets, and a special method of interpolation was used to avoid the necessity of examining every compartment for every station. On account of these special methods, each computation for a circle of a radius of more than 4,000 kilometers around a station required only about ten hours for one computer. More than two hundred such computations have been made to date.

The third step in the investigation is to compute by the method of least squares the most probable value of the five unknowns, namely, the corrections to the assumed value of the equatorial radius of the spheroid, to the assumed flattening of the spheroid, to the assumed initial latitude, initial longitude, and initial azimuth. The observation equations were established from formulæ applicable to areas rather than to arcs, as indicated earlier in this paper. The absolute terms of the observation equations depended upon the deflections of the vertical, and, for the purposes of the investigation, three sets of absolute terms were used, as follows:

First, a solution was made by using the observed deflections of the vertical—that is, simply the differences between the astronomic and the geodetic values. This is the usual solution and corresponds to the assumption of complete isostatic compensation for every detail of topography and with the compensation very close to the surface.

Second, a solution was made after correcting the observed deflections of the vertical for the known topography within a radius of 4,126 kilometers of each station. This solution corresponds to the assumption of extreme rigidity.

Third, a solution was made upon the assumption that there is complete isostatic compensation and that the compensation for the excess or defect of mass, above or below sea level, is in the form of a defect or excess of density uniformly distributed upon an average through the first 205 miles of depth.

This third step of the investigation has been completed only for a group of stations which will be called the central group, comprising about one-fourth of those which will be used in the complete investigation. The central group includes the stations along the thirty-ninth parallel triangulation from Ohio to Kansas, inclusive, and those on

the Lake Survey triangulation from southern Illinois to the north shore of Lake Superior. The range in longitude is 18° and in latitude 10°.

The three least-square solutions furnished residuals which served to test the validity of the three assumptions on which the solutions were based. That one of the three solutions for which the residuals are smallest, or, more accurately, for which the sum of the squares of the residuals is smallest, is presumably based on the assumption which is nearest the truth. This test indicates that the assumption of extreme rigidity is far from the truth. It also indicates that the assumption of isostatic compensation distributed throughout the first 205 miles of depth is nearer to the truth than the first assumption, namely, of complete and shallow isostatic compensation. An approximate test shows that if the assumed distance 205 miles is made either much greater or much less, the residuals will be increased, and that, therefore, 205 miles is the most probable value of the depth of compensation.

The conclusion that for the eastern half of the United States and the adjacent portion of the Atlantic the theory of isostasy is true, to a considerable extent, is reasonably safe. The conclusion that the depth within which the isostatic compensation takes place is 205 miles is one which may be modified considerably as the investigation proceeds.

The investigation thus far leaves the signs of the corrections to the constants of the Clarke spheroid of 1866 uncertain.

For the sake of clearness it may be well to recall the relation between the effects upon the deflection of the vertical of a given excess of mass above sea level, a mountain, for example, upon the assumption of extreme rigidity on the one hand, and upon the assumption that an isostatic compensation exists distributed uniformly to a given depth, say 205 miles, on the other hand. In the first case the mass of the mountain has its full effect at the station according to the law of the inverse square. In the second case, if the station is at a considerable distance, say 1,000 miles from the mountain, the defect of mass in the form of a deficiency of density distributed through a depth of 205 miles below the mountain is also nearly in a horizontal line from the station and therefore produces a deflection at the station which nearly counterbalances the direct effect of the mountain. If, on the other hand, the station is very near to the mountain, say within 5 miles, the mountain mass has its full effect on the deflection, but the subterranean defect of mass being nearly directly below the station hardly affects the deflection at the station, although it does reduce the value of gravity there. If the depth of compensation is 205 miles, the factors by which the topographic deflections computed on the assumption of extreme rigidity must be multiplied to obtain the deflections corresponding to the isostatic conditions are 0.99 for topography at a distance of 2½ miles, 0.95 for 10 miles, 0.6 for 100 miles, and 0.01 for topography at a distance of 2,000 miles.

For four widely separated stations the topographic deflections computed on these two assumptions are given below.

	In meridian.			In prime vertical.		
	Assumption of extreme rigidity.	Assumption of isostatic compensation 205 miles in depth.	Difference.	Assumption of extreme rigidity.	Assumption of isostatic compensation 205 miles in depth.	Difference.
	"	"	"	"	"	"
Calais, Me	−32.26	−2.80	29.46	−32.33	−2.85	29.48
Knott Island, Va.[a]	−31.30	−3.72	27.58	−54.30	−7.96	46.34
New Orleans, La	−27.35	−3.13	24.22	−14.59	−1.09	13.50
Minnesota Point, N. B., Minn.[b]	− 6.27	−2.14	4.13	−16.37	−3.72	12.65

[a] Near the extreme southeast corner of Virginia. [b] Near Duluth, Minn.

When it is recalled that in so far as mere errors of observation are concerned the deflection of the vertical at any point is determined within 2″ it seems evident that the observations are competent to determine to what extent and the manner in which the isostatic compensation exists. The difference between the two assumptions as shown by the table is frequently ten times and sometimes twenty times as great as the error of observation.

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PHOTOGRAPHIC METHODS EMPLOYED BY THE CANADIAN TOPOGRAPHICAL SURVEY

By ARTHUR O. WHEELER, F. R. G. S., Topographer Department of the Interior, Canada

GENERAL PRINCIPLES OF THE METHOD

In order to understand the following notes, it is necessary to state briefly the general principles. Practically speaking, the photographs are perspectives from which, by the rules of geometry and the inverse problem of perspective, the visible lines or points defining topographical features therein seen may be projected upon a ground plan. It is essential that the features to be mapped be seen in at least two views taken from stations some distance apart, and of which the position and elevation above a given datum, generally sea level, have been ascertained.

The two stations and the point to be projected should form a fairly well-conditioned triangle, i. e., the line drawn between the stations would be a base subtending an angle of which the point is at the apex, the accuracy with which it is projected depending entirely upon the closeness of the angle to 90°.

A topographical map usually consists of contour lines, which represent the projection on the plan of the imaginary lines following the inequalities of the surface at given intervals of altitude.

On the plan, the points are placed in position by projecting thereon the traces of the horizon and principal lines of the two or more views employed, and the lines of sight from each camera station to the said points. The intersection of the projections of the lines of sight fixes the position of the points. The traces of the horizon and principal lines are required for platting these lines of direction. By inserting needles at the camera stations and using a fine silk thread, or better still a hair from a lady's head, as has been suggested to the writer by a well-known gentleman of the United States Geological Survey, the work is made mechanical and can be performed through a series of points very rapidly.

A sufficient number of points along the ridges and dividing water courses of the area embraced are determined from the photographs to enable an accurate delineation within the scale of the map to be made upon the plan.

The elevation of the points so determined are based upon the eleva-

tion of the stations from which the views are taken and are obtained directly from the photographs. The horizon line of a view corresponds to the altitude of the station. The elevation of any point in a photograph is proportional to its height above or below the horizon line and the distance that its projection falls within or beyond the trace of that horizon line. A scale may readily be constructed to permit these elevations to be taken out rapidly. Elevations should be taken out from all the views employed to fix the position of a point, and thus made to check one another. The points thus determined in position and altitude permit contour lines to be drawn at any suitable equidistance.

The position and relative elevations of the camera stations are ascertained by the ordinary methods of a trigonometric survey carried to a greater or less degree of refinement. The accuracy and detail of the mapping is dependent upon the precision of the base work, the number of camera stations, and the scale of the map. The method is very similar to that of the plane table, with the following exceptions: With the plane table most of the platting is done in the field; with the camera the same work is done in the office. With the plane table you can occupy but one station at a time; with the camera, when platting, you practically occupy both at once. You then have before you at the same moment the views taken at the two stations, and thus see the ground simultaneously from both points of view. This is a very strong factor in the identification of points. On the other hand, the most perfect photographs are but a weak representation of nature's contrasts, and the delicate inflections of light and shadow are much impaired by transition through the camera lens and reproduction on the best of sensitized plates.

The above are the fundamental principles of the method; there are, however, numerous geometric constructions that assist in obtaining elevations and definitions of figures in planes parallel or inclined to the ground plane. For the most part these require the use of perspective instruments, such as the perspectograph, perspectometer, centrolinead, and photograph board. While materially assisting the delineation and rendering the construction of a map of much greater scientific interest, they can, for the most part, be dispensed with.

The method is applicable to topographical delineations in all classes of country where there is sufficient definition of contours and contrast of features to permit of the identification of points, and may be advantageously used in individual cases, such as rivers flowing through timbered valleys, lakes, irrigation systems, towns, villages, parks, roads, etc., wherever suitable camera stations can be had at sufficient elevation to disclose the details of the area to be mapped. Above all, however, is it suited to the definition of rugged and snow-clad mountainous country where the season between snow and snow is short, during

which time alone peaks can be climbed in safety, and then can only be occupied for an hour or two. In a country of this nature, subject to high winds and sudden fluctuations of climate, the plane table and all ordinary methods of survey are impossible.

FIXING OF STATIONS IN POSITION AND ALTITUDE

It is necessary that some system of control should be outlined prior to commencing the photographic work. This may vary from a primary and secondary triangulation of a high degree of accuracy, where the photography is carried on independently from subsequently selected stations, to a mere reconnaissance survey when, starting from an established base line, the triangulation and photography are carried along together.

To fix camera stations in position four methods may be adopted: (1) If close to a triangulation station, by taking at the station the azimuth from another primary or secondary point and measuring the distance with a tape. This is the easiest and most accurate method. (2) If distant from a triangulation station, or an independent summit, by erecting a signal and reading upon it with a transit or theodolite from outside fixed points. (3) By taking one reading upon it from an outside fixed point and at the station two readings on other fixed points. (4) By taking four or more readings at the station on outside fixed points.

To utilize the third and fourth methods when constructing the map, the readings are plotted on tracing paper and lines are drawn in the directions obtained. The paper is then shifted around until each line passes through the station to which it belongs. The point from which the lines radiate is then at the location of the station to be fixed and may be pricked through.

This last method may be advantageously used in the absence of an organized system of triangulation, when the survey is of an exploratory nature and is not carried to a very high degree of accuracy.

DATUM, SCALE, EQUIDISTANCE

Topographical maps are usually referred to sea level as a datum. In order to ascertain this the altitude of some point of the survey must be established either by barometric or trigonometric leveling, or by hypsometrical observations, or, as in the example to be presented, by reference to the levels of a main line of railway carried from ocean to ocean. Any datum, however, can be assumed with reference to some known and definitely fixed point or topographical feature which can subsequently be determined in altitude.

Any scale may be used and any contour equidistance, from 10 feet up. The larger the scale and the shorter the equidistance the more laborious the plot and the greater the number of camera stations required, owing to the increase of detail.

For signals along the railway and at stations not far above timber line, a pole 10 to 12 feet long, surmounted by a white flag, was set up, and white cotton targets placed at right angles were used for sighting upon. At long distances above timber line rock cairns, 5 to 7 feet high, were erected. In both cases the signals answered all requirements of the distances at which they were employed.

MAP OF THE SELKIRK RANGE ADJACENT TO THE CANADIAN PACIFIC RAILWAY

The map prepared is on a scale of 1:60,000 in the larger copy and 1:190,080, or 3 miles to an inch, in the smaller. It covers an area of 1,100 square miles and embodies the roughest, wildest, and grandest portion of the range. Field work was commenced early in July, 1901, at Albert Canyon village, a point about 22 miles from the Columbia Valley at Revelstoke. Signals were set on the surrounding mountains and at intervals along the railway, and readings and photographic views taken from each, respectively, or from suitable camera stations closely adjacent. The work was expanded westward on both sides of the track to the Columbia Valley, where a 5-mile tangent along the Arrow Lakes branch of the Canadian Pacific Railway offered a suitable base. About the middle of August it was found necessary to leave the Columbia Valley district owing to dense smoke from forest fires, and work was taken up at the summit of the range and produced westerly to tie in with that commenced at Albert Canyon. The field work closed at the end of October. The following year, 1902, the survey was extended northward and southward from Rogers Pass to cover the tourist portion of the range, commencing at the end of July and terminating at the end of October. Thus the field work extended over a period of seven months, a considerable portion of which was unavailable owing to dense smoke from bush fires and cloudy and wet weather, the two last being highly detrimental factors in the Selkirks, where the annual precipitation is very heavy.

In 1896 and 1897 an accurate traverse survey had been made of the Canadian Pacific Railway through the mountains, and this survey, in conjunction with the construction levels from ocean to ocean, was now used as a base of reference for geographical position and for altitude. The method of trigonometric levels was employed to obtain the latter, and the results shown upon the map are the mean of a series of readings to and from other stations and signals erected at intervals along the line of railway. The distance between camera stations ranges from 1 to 10 miles, but is more generally in the neighborhood of 5 miles.

In the field the work was carried on by a party of six—the writer, two assistants, two packers, and a cook. The transport was chiefly by pack ponies and, where trails did not exist and ponies could not be


SKETCH MAP
Showing the
HIGH PEAKS OF THE SELKIRKS
Adjacent to the line of the
CANADIAN PACIFIC RAILWAY
From Photo-Topographic Surveys, by Arthur O. Wheeler F.R.G.S.
1902
N
HERMIT RANGE
Beaver River
Grizzly Creek
Bear Creek
Rogers Pass
Mt Avalanche
Eagle Pk.
Mt Sir Donald
Mt Tupper
Hermit
Swiss Pk.
Rogers Pk.
Mt Grizzly
Ursus Major
Cheops
Napoleon
Illecillewaet River
Asulkan Creek
Mt Abbott
Mt Afton
Mt Lookout
Névé
Illecillewaet Névé
Mt Macoun
Mt Bonney
Mt Swanzy
Castor
Pollux
Clarke Pk.
Geikie Gl.
Deville Gl.
Mt Fox
Mt Topham
Mt Deville
Mt Dawson
Mt Donkin
Mitre Gl.
Fish Creek
Flat Creek
Oliver Pk.
Mt Purity
Mt McBean
Wheeler
Grand Gl.
Beaver Gl.
Duncan Gl.
Mt Sugarloaf
Mt Beaver
Mt Duncan
Battle Cr.
Duncan R.
Copperstain
Spillimacheen River
SCALE OF MILES
1 0 1 2 3 4 5
Photo-Trigonometrical Stations
---- Trails
Stations from which computations were made
117°40′
117°35′
117°30′
117°25′
117°20′
117°15′

INSTRUMENTS

Of surveying cameras and field instruments used in connection with photographic surveying, a large number have been invented. The Canadian equipment, designed by Mr. E. Deville, surveyor-general of Dominion lands, consists of a plain fixed-focus camera and ordinary transit-theodolite with short, stout tripod adapted to receive either.

The transit has a 3-inch circle reading to minutes, with vertical circle attached to the telescope. The tripod is 3 feet 4 inches long, and has sliding legs which reduce the length to 20 inches. It packs in the outer case of the transit box. The whole is adjusted by straps for carrying and weighs 15 pounds.

The camera is an oblong metal box open at one end. It is fitted in an outside wooden case. Cross levels are attached to the metal box in two positions, the longer of which has been dubbed "the horizontal" and the shorter "the vertical." Plates are used. Films have been tried, but were found to be insufficiently free from distortion when passing through the developing process. Each plate is carried in a single holder, the outer case of the camera being fitted with a box to contain a dozen. Foot screws are adapted to the lower side of the camera in either position, and permit of its being accurately leveled.

It is absolutely essential that views should be taken on plates in a vertical position; it is therefore necessary that the reading of the levels to secure such a position should be obtained before commencing the survey. This is a rather delicate operation and requires some skill. The focal length of the camera is marked on the edge of the metal box against which the plate presses, and is registered on every view taken; consequently it appears upon each working print.

The lens is a Zeiss anastigmat, No. 3, of series V, the aperture F 18 and the focus 141 millimeters; a deep orange screen is used in front. With a medium-speed isochromatic plate the unit of exposure varies from fifteen to twenty-five seconds.

Plates are 6½ by 4¾ inches, and furnish bromide enlargements for plotting purposes of about 10 by 14 inches.

In the horizontal position the lens covers about 56° of arc, and 7 plates are required to complete a circuit, allowing for overlap. In the vertical position the lens covers about 37° of arc and 11 plates are required.

The camera and dozen plates fit together in an outside leather case with straps for carrying, and weigh about 20 pounds. The equipment has been found to work well. It is very portable and, owing to the short tripod which is fitted with a canvas bag and can be loaded with rock, is extremely rigid, a most important factor in a class of country where high winds are prevalent. This lack of rigidity would appear sometimes to be a deterring factor in the use of combination instru-

ments and instruments of complicated design. Plates showing the camera and transit-theodolite in use are now submitted; also prints and map showing some of the constructions.

APPLICATION OF PHOTOGRAPHIC METHODS TO GEOGRAPHIC EXPLORATIONS

While photographic methods are undoubtedly suited to the delineation of highly accented topographical areas over which an accurate system of control has been extended, it would appear to the writer that they are also specially adapted to quick reconnaissance surveys and to geographical exploration. Explorations of this character are frequently carried up the valleys of main waterways and extended over important lake basins. This is usually accomplished by some form of traverse using magnetic bearings for direction and rate of travel reckoning for distance, checked by astronomical observations for latitude and astronomical observations or chronometer reckoning for longitude. Altitudes are generally obtained by means of barometric levels. In such cases photographic methods can be substituted to great advantage. Both methods start from the same data. By carrying a quick triangulation up a river valley or spreading it over a lake basin or any other desired area, a more rapid and more accurate result can be obtained—provided, of course, there are points of sufficient altitude bounding or within the area to display it in detail to the camera. It may be contended that the occupation of each camera station entails an arduous climb. This, however, would furnish no objection to those really in earnest. Two persons only are essential to the camera and transit work, and in most countries porters can readily be had. A strong point in its favor is that the altitude is carried by angles of depression and elevation from point to point read back and forth between stations, and all others are taken direct from the views. In each view it would be necessary to select a suitable orientation point for direction of the view; this is readily done by reading an azimuth to one of the triangulation stations.

The method can be used either separately or in conjunction with any other, and barometric levels can be carried at the same time as the trigonometric ones. It furnishes, however, the immense advantage of securing for future record a connected series of photographic views, each of which covers an area of the country explored that can be definitely laid down upon a map.

There are three special constructions that would apply in the cases of exploration indicated above:

1. The method of squares is particularly applicable to the delineation of rivers, large and small, flowing through wide bottoms that may be heavily timbered and inaccessible to travel except by the waterway itself. Here, from the surrounding heights of the valley, a bird's-eye view can probably be obtained, where all the windings and side

channels, islands, and other details are displayed as on a map. The perspective of a series of squares is now drawn upon the photographic view covering any section of the stream and a corresponding series of squares drawn in proper position upon the plan. The channels, islands, etc., are then drawn at sight, square by square. It will be readily seen that such a delineation could not be obtained by ordinary methods of traverse except at great expenditure of time and money, as it would be impracticable to follow every channel or to delineate every island.

The same construction applies to any particular lake or series of lakes by occupying connected camera stations around their respective basins. The plane table is generally used for the survey of any special features, such as those named, entailing a large amount of map construction in the field; by the photographic method the map work can be done entirely in the office upon the explorer's return. It is needless to dwell upon the advantages of this arrangement.

2. A second construction is especially adapted to the configuration of topographical features lying in planes practically parallel to the horizon plane of the camera station, such as lakes, stretches of coast line, swamps with streams winding through them, salt marshes, and prairie openings in timbered areas. It is only necessary to know the altitude of the camera station and the altitude of the plane in which the feature lies. With this data, the delineation can be made from a single view of such portion as may be covered thereby.

Having selected in the view a sufficient number of points to enable the feature or various parts thereof to be sketched, the traces of the horizon and principal lines of view are laid down on the plan. The points selected are now projected on the trace of the horizon line and lines are drawn to them from the camera station. To the right or left and parallel to the principal line a line is drawn at a distance equal to the difference in altitude of the camera station and the plane of the feature to be drawn. The distances of the respective points below the horizon line of the view are now laid off on this line, measuring from the trace of the horizon line upon the plan and lines drawn through them parallel to the said trace. Their intersections with the lines previously drawn from the camera station to the several projections of the points on the trace of the horizon line establish the relative positions of the points upon the plan and the bounding lines of the feature to be mapped can be drawn through them at sight.

The same results could be achieved by the method of squares, but it would then be necessary to obtain a new ground plane for each view of the series, whereas in the present case, once the altitude of the plane parallel to the horizon plane of the camera station is found, it applies throughout the series.

3. Another feature in conjunction with the conduct of an explora-

tion survey by photographic methods appears to the writer to be the facilities it affords to ascertain the altitude of surrounding peaks in mountainous or semimountainous country with a considerable degree of accuracy.

While conducting the survey of which the map is now submitted, the writer had occasion to take a series of views from commanding Selkirk points in which a number of the highest peaks of the adjacent Rocky Mountains were visible. Among others Mounts Columbia, Bryce, Lyell, and Forbes, as best known, were easily identified.

Having platted the Selkirk triangulation, the attempt was made, as a matter of experiment, to compute from the photographs the greatest altitudes of the peaks named. The methods employed were the same as those used in the ordinary reduction of altitudes for points used in contouring. The positions of the peaks were first laid down from the photographs and the distances scaled. The differences in elevation were next computed and a correction was applied for curvature and refraction.

In order to ascertain what degree of reliability might be placed upon the computation of altitudes at so great a distance, the altitude of Chancellor Peak—a peak of the main range—was first computed. This altitude had previously been established by the topographical survey, from a series of angular readings, at 10,780 feet above sea level. It was now computed from four Selkirk views and the mean result found to be 10,751 feet, with a range of 41 feet, or 29 feet less than that previously established. The distance between the extreme stations of the views employed was a little over 18 miles, and the mean distance to Chancellor Peak was 45 miles. The result seemed to promise altitudes for the four northern peaks that would be a close approximation to the truth.

The Mount Columbia computation, made from views at four different stations, gave a mean altitude of 12,723 feet, with a range of 261 feet.

Mount Bryce was a mean of six stations and the resultant altitude 11,685 feet, with a range of 235 feet.

Mount Lyell, computed from four stations, showed a mean altitude of 11,459 feet, with a range of 271 feet.

Mount Forbes, from four stations, mean altitude 12,069 feet, with a range of 355 feet.

In each case the extreme distance apart of the computing stations was a little over 18 miles. The large increase in the range over the Chancellor Peak computation is accounted for by the fact that while the peak named is almost directly opposite the center of the 18-mile base, the lines of sight to the more northerly peaks become oblique and consequently a greater difficulty is met in platting their position accurately at so great a distance.

The average distance of Chancellor Peak from the stations occupied is about 45 miles; Forbes, about 50 miles; Lyell, about 52 miles; Bryce, about 58 miles, and Columbia, about 62 miles.

No instrumental readings were taken upon any of the peaks named, and the results were obtained absolutely from the photographs.

A table has been attached showing the stations from which the computations were made. They appear upon the map now submitted. A second table shows the results of previous computations of the heights of these four peaks obtained from barometric readings. It will be noted how closely they are corroborated by the photographic results, for which it was only necessary to take a few views at distances varying from 40 to 60 miles.

TABLE No. I.

Peak determined.	Selkirk station from which determined.	Computed altitude.	Mean altitude above sea level.	Mean range.
		Feet.	*Feet.*	*Feet*
Mount Columbia	Mount Hermit	12,795	12,740	261
	Névé	12,747		
	Beaver Overlook	12,839		
	Mount Wheeler	12,578		
Mount Bryce	Mount Hermit	11,763	11,686	235
	Mount Bagheera	11,678		
	Catamount Peak	11,592		
	Névé	11,682		
	Mount Wheeler	11,582		
	Beaver Overlook	11,817		
Mount Lyell	Mount Hermit	11,610	11,463	271
	Mount Wheeler	11,339		
	Névé	11,383		
	Beaver Overlook	11,520		
Mount Forbes	Mount Hermit	12,101	12,075	355
	Névé	11,989		
	Mount Wheeler	11,928		
	Beaver Overlook	12,283		
The Chancellor	Mount Wheeler	10,770	10,751	44
	Névé	10,726		
	Mount Fox	10,764		
	Rogers Peak	10,755		

TABLE II.—*Comparative altitudes.*

Peak determined.	Dr. N. J. Collie.	Rev. J. Outram.	A. O. Wheeler, from Selkirk triangulation.
Mount Columbia	[a] 12,500	12,500	12,740
Mount Bryce	[a] 12,000	11,800	11,686
Mount Lyell	[a] 11,500	11,900	11,463
Mount Forbes	[a] 12,000	12,500	12,075

[a] Note on Doctor Collie's map: "Heights marked with an asterisk approximate only."

NOTE.—The Selkirk deductions are of special interest in that they closely corroborate previous results obtained from a different base by totally different methods.

RECENT PROGRESS IN DETERMINING GEOGRAPHICAL POSITIONS

By Dr. ADOLF MARCUSE, University of Berlin

According to the different instruments and methods we have to take into separate consideration the recent progress, (1) in determining geographical positions on land, (2) in finding the ship's position at sea, (3) in ascertaining the position of a balloon in the air.

(1) LAND OBSERVATIONS

The actual progress consists in applying photographic work, either by using a simple photographic zenith camera or by employing a small photographic universal instrument. The instruments of the first kind, giving only latitude and time, are principally those of Schnaudle (Potsdam) and Schwarzschild (Göttingen). They have, however, two serious disadvantages, allowing only a very limited use in observations near the zenith and not being controlled at all by visual observations. On the contrary, the photographic universal instrument or the photo-theodolite, constructed for both photographic and visual work, and giving latitude, time, longitude, and azimuth, allow much more general applications. The principal instruments of this kind are the photo-theodolite of Koppe (Braunschweig) and the photographic universal instrument of Marcuse (Berlin), made in two different forms.

(2) SEA OBSERVATIONS

Usual reflecting instruments have the great disadvantage of being dependent on the natural horizon line. In dark or cloudy weather this line fails entirely, and in case of great differences between air and water temperatures very inconvenient and abnormal elevations of the horizon line take place, gaining so many minutes of arc and changing constantly. These inconveniences can be partly removed by using the special tables of Koss (Pola), taking into consideration for the values of horizon dip the actual differences of air and water temperatures.[a] At the same time Koss has constructed a special Kimm prism, to be

[a] Nautical Astronomical Ephemeris of Trieste.

used on the ordinary sextant to determine at any moment the dip of horizon.

But the safest way to eliminate such considerable errors and to be entirely independent of the natural horizon line, consists in using the gyroscop-collimator of Fleuriais (Paris) in connection with the sextant. This ingenious little apparatus gives within one minute of arc an artificial horizon line by the rotation of a little turbine driven by air, which shows dark lines through lenses mounted at right angles to the arcs of the turbine.

(3) AIR OBSERVATIONS

To determine the geographical position in the balloon is not only a new but a very important problem, especially for long and high air voyages. When the earth's surface is visible from the balloon the aeronaut easily obtains his position by direct or photogrametric sight of known terrestrial objects. But very often, mostly at high elevations, nothing but sky is visible. In that case the position must be determined by astronomical observations in daytime of the sun, during the night of stars. Observations of this kind must be quickly and easily made, and the best instrument for it is the level-quadrant of Batenschur (Hamburg).

In the rare case, finally, when neither the earth's surface nor the sky can be seen, the approximate latitude of the balloon's place might be determined by observing the horizontal magnetic force, whose intensity follows certain direction lines in harmony with the latitude parallels on the earth. The best instrument for this kind of observations is the electric apparatus of Ebert (Munich).

After this brief account of new progress in the instrumental art of observing geographical positions, a few words may be added upon recent development in the methods of calculation. It is impossible to give here a complete account of this branch, but attention might be called to a new and important extension of the old and famous American Turner method for determining approximate positions within at least one minute of arc. I mean the method of "increasing latitudes," or especially the theory of "Mercator functions," lately developed by Bärgen. In connection with this theory short and very convenient tables[a] exist, which give without any logarithmic trigonometrical computation all the necessary solutions for determining geographical positions. Eleven pages of these new tables published by Bärgen (Wilhelmshaven) replace a whole collection of logarithmic trigonometric tables. Only two Mercator functions instead of six trigonometric functions are necessary; all the resulting terms are connected only in an algebraic way; and calculations are equally exact for all angles of the Mercator functions, even near their limit values.

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[a] Archiv N. Deutschen Seewarte, Hamburg.

PLAN OF A MAP OF THE WORLD—RECENT PROGRESS IN THE EXECUTION OF A MAP OF THE WORLD ON THE UNIFORM SCALE OF 1 : 1,000,000 (16 MILES TO THE INCH)

By Dr. ALBRECHT PENCK, of the University of Vienna

The Fifth International Geographical Congress, held at Berne in 1891, resolved to consider the plan of a map of the world on the uniform scale of 1: 1,000,000, the sheets of which were preferably to be limited by meridians and parallels. A committee was appointed to deliberate on the question, and I had the honor of transmitting to it special propositions for such a map. But the work of the committee made no progress, and a formal invitation to the different States to nominate special delegates to join the committee was not successful. The congresses held at London in 1895 and at Berlin in 1899 could also not do much for the plan, and thus it seemed to many as if the plan would not be carried out.

In the last five years the situation has totally changed, and I am happy to be able to show to this congress three maps which are prepared essentially according to the specifications for a map of the world on the scale 1: 1,000,000. France made the first steps. The geographical service of the army had several years before studied in detail the propositions for such a map, and when the Cuban war and the disturbances in Persia and in China attracted the attention of military men to the Antilles, Persia, and China, the French service issued a series of maps of those parts of the world on the uniform scale of 1: 1,000,000, limited by parallels and meridians. These sheets appear by execution and arrangement as parts of a general map of the world. Thirty-one sheets are already issued, 20 are in progress, and 6 planned.

The cartographical department of the royal Prussian land survey has begun to publish a map of eastern China on the same scale of 1:1,000,000, the sheets here also being limited by meridians and nearly by parallels. Though this map intends to represent only eastern China, it adopts the scheme of a map of the world. Twenty-two sheets are planned, of which two are already completed. Finally, the much-discussed projection of a map of India on the scale of 1:1,000,000, with sheets limited by parallels and meridians, induced the intelligence

division of the war office at London to begin the publication on this scale and projection of a large map of Africa, which will embrace not less than 132 sheets, similarly limited. Eighteen of them have already appeared. Thus we have received in the last four years from France, Germany, and Great Britain three series of maps containing 61 sheets, which are worked out on the same scale and on the same style of division of sheets. The maps cover large parts of the earth, nearly 10,000,000 square miles being represented on them, and they will ultimately embrace a whole continent, Africa, and very large parts of another, Asia, and parts of America. The maps realize in a large measure the proportions for a map of the world. They are executed on the same scale and represent parts of the earth's surface in such a way that they suffer almost nothing by the deformations of the chosen projection, each sheet of the French and English map being represented on its own plane, which is a face of the sphere of the earth, and the German maps being drawn on a cone, which touches the earth in China in such a way that there is only a very little amount of deformation.

It is thus for the first time that distant parts of the earth's surface are represented so that they can be directly compared with one another. One who is familiar with Cuba needs only to lay the French map of this island at the side of the German or French map of China to see at one glance the space which has been overwhelmed in the Russian-Japanese war. A student of the coast lines can now compare the bays of Shantung with those of Cuba, and another can compare the behavior of the rivers in south Abyssinia with those in south China, and a third will be able by the chosen projection to determine the exact areas of lands, rivers, basins, lakes, and so on.

All this indicates considerable progress in the practical and theoretical study of different parts of the world, a progress which is not essentially affected by the fact that the maps are not so uniform as was desirable. Uniformity reigns as to scale and nearly as to the limitation of the sheets, each of them embracing a surface lying between 4° of latitude and 6° of longitude, but their arrangement is based upon different parallels and meridians. The English and the French maps use the equator as the initial parallel of the sheets; the German sheets, however, use the parallel of 2° north. Still greater variety reigns as to the limiting meridians. The English maps use as the initial meridian of the sheets that of Greenwich; the German that of 4° east longitude; the French that of Paris. The French sheets of China do not, therefore, correspond to the German sheets of China, and if the Indian map be executed and the French map is extended over larger areas of Asia, as planned, its sheets will overlap the Indian sheets. Thus much double work will be done, and the English and French maps can not be directly joined. The same trouble will happen with the Eng-

lish and German maps. We have in the English, French, and German maps not sheets of one map, but sheets of different maps, though each of these maps realizes the advantages of a map of the world.

In execution the different maps are based on the same principles that are proposed for a map of the world and now in general use. Water is represented blue, mountains by brown or gray shading or sketched contour lines; names and some ways of communication black, on the German and the French map partly red. But there are differences in the adopted signs for towns and in the style of lettering the names, though each separates duly the names of rivers, mountains, and townships by the character of the lettering. Greater differences exist in the measures adopted for height indications; the German and French maps use the meter, the English the foot. The greatest differences, however, lie in the orthography of names and in the fact that we see on the several series of sheets geographical terms in different languages. In all these respects the maps stand on a national and not on an international basis, and do not show that uniformity which one might wish for a map of the world. But it must be admitted that in many of these respects close uniformity can be reached. The state of our geographical knowledge does not allow us to represent all countries with the same degree of accuracy; there can not be perfect uniformity in their representation; there will always necessarily be a certain liberty of representing unlike phenomena. The orthography used by the civilized nations being different, there can be no uniform orthography of geographical names, and the international orthography must depend for all those countries which use the Latin alphabet on a national base. Uniformity can be reached only as to scale, as to the projection of each sheet on its own plane, and as to the adopted geographical units. As to these three points, the first is quite and the second nearly uniformly treated in our maps; differences exist only as to the third, and here I believe that the congress could advance future work very much by a resolution in favor of a certain initial meridian and of the geographical measurements to be used on a map of the world. This resolution should, in my opinion, be in favor of the initial meridian of Greenwich and of the metric system, the latter being now introduced in many different countries of the world, and being technically adopted both in the United States and in Great Britain.

But an international geographical congress held in America could go still further. There are now more than 40,000,000 of kilometers, approximately a fourth part of the surface of the land, in process of being represented on maps on the same scale of 1 : 1,000,000, with important common features, and this quarter of the land belongs for the most part to the Old World, although a few American sheets have been executed by France. It would be a very important result of the

congress if it could induce the United S
Great Britain is doing for Africa i. e.,
both continents of America. The want
1 : 1,000,000 is felt very much, not only
continent only a few States, as Argenti
and a still larger one, but also for Canada
States. Wonderful work has been done i
raphers; excellent maps are edited by th
logical Survey. The coasts are prepared
interior on the scale of 1 : 62,500, 1 : 1
1 : 250,000; but there is such a want of
the United States is much at a loss wha
I studied this question seriously when
sions of the congress, and finally I fou
of the United States are made in Ger
the new Stieler Atlas as companions;
had already accompanied me to the
proved very satisfactory. They conta
afford. This is 1 : 3,700,000. But th
cient for containing such details as a
is far too little to give the impression
The scale of 1 : 1,000,000 would be a
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The atlases of Vivende Saint Mirti
Berghaus, have adopted uniformly
Europe and France, and in those
for a map of large parts of Euro

A map of America on the sca
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bottom of the bordering seas, as is done by the French map, and the inland lakes, for which sufficient soundings already exist. Geographical orthography presents for America no difficulties, for only three languages are officially adopted in the different countries—English, Spanish, and Portuguese. They afford the standard for writing geographical names; Indian names must be given in that form which is usual in the several countries. Thus on this point uniformity could be more easily reached than in other parts of the world.

The geographical congress may be proud to have advanced by its resolutions in former meetings the execution of three great maps, which will cover one-third of all land. It should recognize, however, the work done by those countries which have acted in the essential points and acted upon its resolutions. It should thank the geographical service of the French army at Paris, the cartographical department of the Prussian survey at Berlin, and the intelligence division of the war office at London, and it should extend the general knowledge of these maps by calling special attention to them. The congress should invite the above-named offices to give an account of their work, accompanied, if it is possible, by parts of the maps in a supplement to its report. But it seems to be especially appropriate that the first geographical congress held in this country should take the first steps toward a general map of America. Thus to the third part of a map of the world, which is now practically in the way of execution, it would add the map of another third of the world. If in this way two-thirds of a general map of the world are started, the completion of the rest of the map can not fail.

NOTICE SUR LES CARTES À L'ÉCHELLE DU 1,000,000^e ACTUELLEMENT EN COURS AU SERVICE GÉOGRAPHIQUE DE L'ARMÉE

Par le Général BERTHAUT, Sous-chef d'état-major général de l'armée, Paris

Le Service géographique de l'armée a actuellement en cours d'exécution et de publication, à l'échelle du 1,000,000^e, des cartes de certaines parties d'Europe, d'Asie et d'Amérique.

Le système de projection employé pour toutes est un système polyédrique; l'origine des méridiens est le méridien de Paris, l'origine des parallèles est l'équateur; chaque feuille mesure 6 degrés sexagésimaux en longitude et 4 en latitude.

Les feuilles, héliogravées sur zinc, sont imprimées en cinq couleurs qui sont:

Le noir pour les écritures, les chemins de fer et les limites administratives.

Le bleu pour l'hydrographie.

Le rouge pour les voies de communication.

Le bistre pour l'estompage orographique.

Le jaune pour les sables.

La teinte bleue qui recouvre la mer a été renforcée le long des côtes jusqu'à la limite déterminée par la courbe bathymétrique 100.

CARTE D'EUROPE

La carte d'Europe au 1,000,000^e a été commencée en 1898.

Ses premières feuilles ont été consacrées à la zone frontière austro-russe; on s'étendit ensuite sur les territoires autrichien, russe, allemand, suisse, italien, français, sur la péninsule des Balkans et la Turquie d'Asie.

Les documents utilisés en totalité ou en partie ont été les suivants:

1° Carte de l'Europe centrale au 750,000^e, publiée par l'Institut géographique militaire de Vienne.

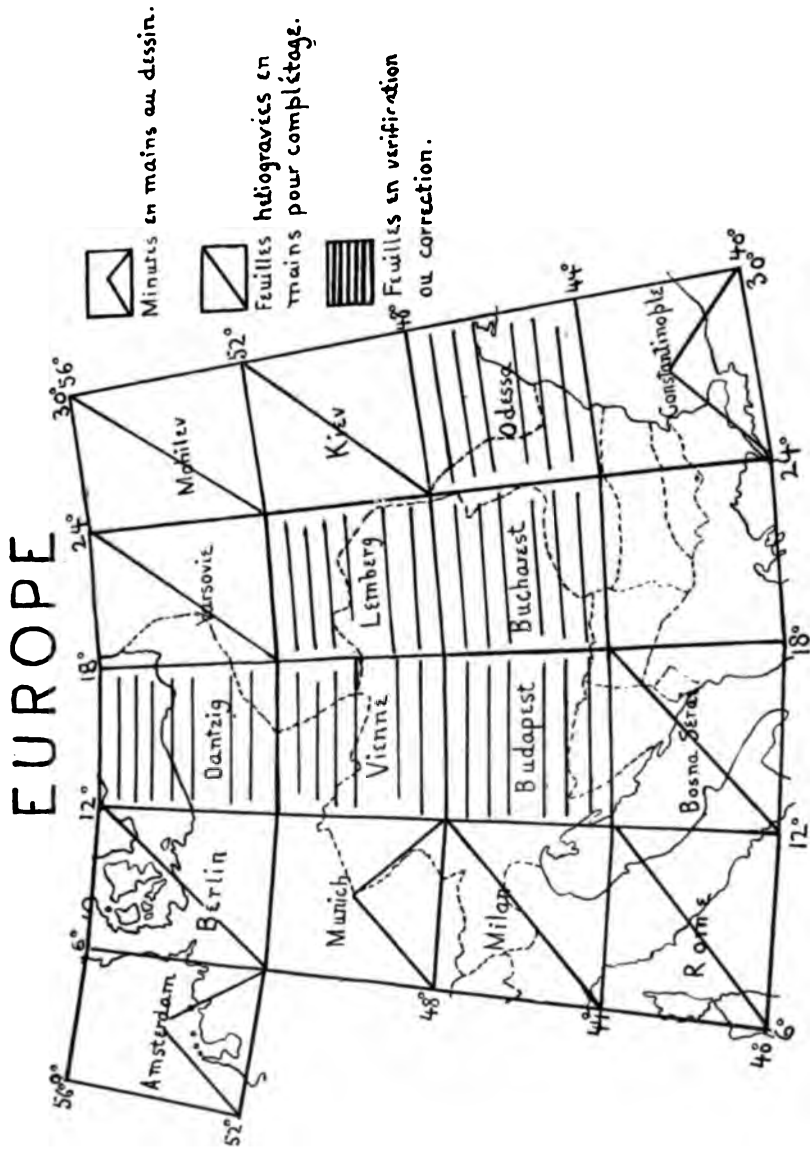
2° Carte de la Russie au 420,000^e, publiée par l'État-major russe.

3° Carte de l'Allemagne au 500,000^e, publiée par la maison J. Perthes.

4° Carte du Danemark au 480,000^e, publiée par l'État-major danois.

5° Carte de la Suède au 500,000^e.

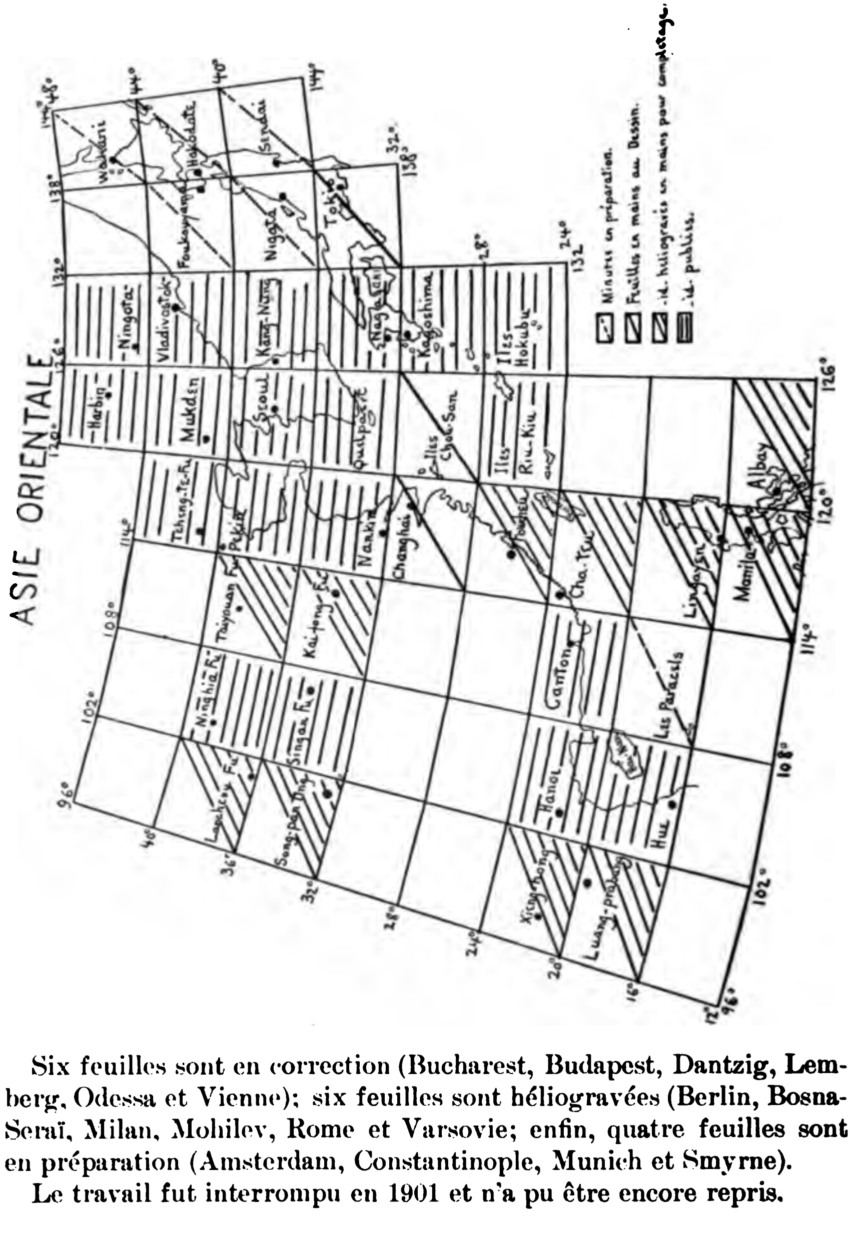
6° Carte de la Suisse au 250,000ᵉ, publiée par le Bureau topographique fédéral.
7° Carte de l'Italie au 500,000ᵉ, publiée par l'Institut militaire de Florence.
8° Carte de France au 500,000ᵉ, publiée par le Service géographique de l'armée.
9° Carte du vilayet de Brousse au 100,000ᵉ, manuscrite.
10° Cartes marines diverses.



Ces documents furent remis aux dessinateurs, ramenés par eux, au moyen du pantographe, à l'échelle uniforme du 750,000ᵉ, puis rédigés à cette échelle. Les minutes furent ensuite réduites, par la photo-

graphie, à l'échelle du 1,000,000ᵉ. Le sélection des couleurs se fit sur les clichés positifs, en grattant sur chacun d'eux les traits qui ne devaient pas être conservés. Puis les planches de couleur furent héliogravées sur zinc.

Les travaux ont porté sur 16 feuilles (voir le tableau d'assemblage No. 1). Aucune feuille n'a encore été publiée.



Six feuilles sont en correction (Bucharest, Budapest, Dantzig, Lemberg, Odessa et Vienne); six feuilles sont héliogravées (Berlin, Bosna-Seraï, Milan, Mohilev, Rome et Varsovie; enfin, quatre feuilles sont en préparation (Amsterdam, Constantinople, Munich et Smyrne).

Le travail fut interrompu en 1901 et n'a pu être encore repris.

CARTE D'ASIE

La carte d'Asie au 1,000,000^e a été commencée en 1897. Ses premières feuilles ont été consacrées à la partie orientale et, dès 1900, il a été possible de faire figurer à l'Exposition universelle un panneau de 9 feuilles représentant le golfe du Pé-Chi-Li, la Corée et une partie du Japon.

La carte d'Asie comporte deux groupements:

Le premier, dénommé Asie orientale, s'étend sur l'empire Chinois (Tibet, Chine, Mongolie et Mandchourie), l'Asie russe, la Corée, le Japon, les Philippines, le Tonkin, l'Annam, le Camboge, le Siam et la Birmanie.

Le second, dénommé Asie centrale, comprend la Perse, l'Afghanistan, ainsi que les zones frontières de l'Angleterre et de la Russie, c'est-à-dire qu'il englobe d'une part, les provinces russes de la Transcaspienne et du Turkestan, et de l'autre, le Kachmir, le Chitral avec les différents pays situés sur la nouvelle frontière de l'Inde britannique.

ASIE ORIENTALE

Les documents qui ont été utilisés pour l'établissement des feuilles de l'Asie Orientale comprennent des cartes russes, anglaises et allemandes, des cartes marines françaises et anglaises, des cartes chinoises et japonaises, des cartes diverses provenant des missionnaires, des itinéraires manuscrits d'attachés militaires français ou d'explorateurs, etc.

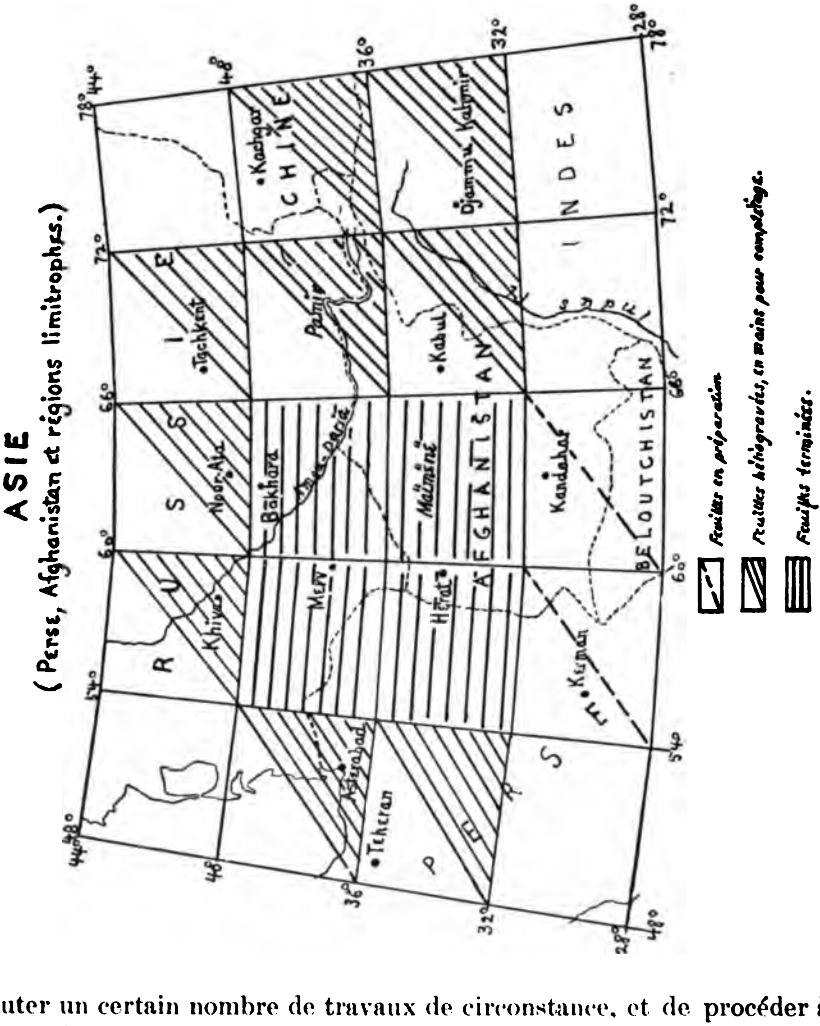
Les plus importants de ces documents sont:

La carte d'État-major russe au 1,680,000^e.
La carte anglaise de Weber au 1,355,000^e.
La carte anglaise de Bretschneider au 4,580,000^e.
La carte de l'État-major allemand au 1,000,000^e.
L'atlas de la Chine de Richthofen au 750,000^e.
La "Karte der Provinz von Shan Tung" de Hassenstein au 660,000^e.
Les itinéraires de Przévalski, de Sven-Hédin.
La "Map of the province of Canton, by Rev. I. G. Lörcher," au 586,000^e.
Les feuilles manuscrites de la province de Kan-Sou, par la procure des missions belges de Chang-Haï.
L'Atlas de la Société des missions étrangères.
Les cartes de l'État-major japonais.
Une carte au 250,000^e en langue coréenne.
Une carte du Kiang-Sou, en caractères chinois.
La carte de la frontière sino-russe en 35 feuilles, au 1,800,000^e, en caractères chinois, etc.

La transcription des noms chinois a été faite, toutes les fois que cela a été possible, par un interprète chinois, en adoptant la prononciation mandarine de Pékin.

L'orthographe employée est celle du Ministère des affaires étrangères.

Les travaux exécutés en 1898 et en 1899 ont eu pour objet la continuation de la carte du littoral de la Chine; mais, en 1900, la production normale des feuilles de l'Asie subit, en raison des évènements qui se produisirent en Chine, à partir du mois de juin de cette année-là, un ralentissement marqué. Le Service géographique, pour faire face aux besoins du corps expéditionnaire, se vit en effet obligé d'exé-



cuter un certain nombre de travaux de circonstance, et de procéder à une mise au courant des feuilles de l'Asie orientale déjà parues. Les différents travaux furent poussés avec assez d'activité pour que le corps expéditionnaire pût être doté de ces divers documents. À ce propos, il y a lieu de noter que le corps français a été le seul des corps expéditionnaires européens qui ait été pourvu de cartes suffisantes et en temps utile.

ASIE CENTRALE

Ces travaux spéciaux une fois terminés, le Service géographique, tout en poursuivant l'exécution des feuilles normales de l'Asie orientale, entreprit également l'établissement au 1,000,000^e du nouveau groupement intitulé "Asie centrale."

Les documents utilisés pour la rédaction de ce nouveau travail peuvent être divisés en cartes générales et cartes spéciales.

Nous citerons en fait de cartes générales:

La carte de la frontière méridionale de la Russie au 1,680,000^e.
La carte de la Russie d'Asie, atlas au 420,000^e.
L'Indian atlas, carte de l'État-major anglais au 253,440^e.
La "Map of the Indian Empire" au 5,000,000^e.
La "Map of the north and southwestern frontier of India."
La carte de l'est de la Sibérie et de la Chine, au 5,040,000^e—carte russe.
L'atlas russe au 210,000^e: Caucase, Turquie, Perse, etc.

Parmi les cartes spéciales, les principales sont:

La carte du Tibet au 506,880^e—État-major anglais.
Le "Northwestern frontier of India."
L' "Afghanistan und seine Nachbarländer"—carte allemande au 3,000,000^e.
La "Map of the Pamir and adjacent territory," au 1,013,376^e.
L'Afghanistan en 4 feuilles, au 1,520,640^e—carte anglaise.
L'itinéraire de Khiva à Boukhara—carte allemande au 3,000,000^e.
La carte du gouvernement de la Caspienne—carte russe.
L'itinéraire de l'Indus à Kaboul, au 500,000^e—carte française, etc.

Les minutes des feuilles de l'Asie sont établies à l'échelle du 800,000^e par les officiers du Service de la cartographie étrangère. Ces minutes sont redessinées par les dessinateurs du Service géographique, à la même échelle, et les nouveaux dessins sont ensuite réduits à l'échelle du 1,000,000^e par la photographie.

La sélection des couleurs se fait sur les clichés positifs. Les planches de couleur sont ensuite héliogravées sur zinc.

Les travaux concernant l'Asie s'étendent, au 1er janvier 1905, à 53 feuilles du type régulier, à l'échelle du 1,000,000^e (dont 38 l'Asie orientale et 15 de l'Asie centrale). Ces 53 feuilles peuvent, en ce qui concerne leur état d'avancement, se décomposer comme il suit:

A.—Asie orientale au 1,000,000^e (voir le tableau d'assemblage No. 2):

6 feuilles en préparation à la Cartographie étrangère.
2 feuilles en mains au dessin.
11 feuilles en mains à l'héliogravure ou à la gravure.
19 feuilles publiées.

Total....38

B.—Asie centrale au 1,000,000^e (voir le tableau d'assemblage No. 3).

2 feuilles en mains à la Cartographie étrangère.
13 feuilles en mains soit à l'héliogravure, soit à la gravure (dont 4 terminées et prêtes à paraître).

Total....15

Les feuilles d'Asie au 1,000,000e, surtout celles d'Asie orientale, ne sont pas définitives. On pourrait même dire que, pour l'instant, la caractéristique de cette carte est d'être continuellement en complétage, en correction et même en réfection totale.

En effet, après le tirage de la première édition d'une feuille, de nouveaux documents intéressant cette feuille parviennent à la Section de cartographie. Ils sont étudiés au Service de la cartographie étrangère, puis, s'il y a lieu, ils sont utilisés pour la préparation de l'un des travaux énumérés ci-après: rectification, complétage, réfection partielle ou totale.

Le plus souvent, ces travaux ne portent que sur la planimétrie; on peut être amené cependant á les executer sur le figuré du terrain.

Ces opérations sont terminées assez rapidement par les officiers du Service de la cartographie étrangère; mais, l'impression se faisant en cinq couleurs, elles demandent un temps très sensiblement plus long pour être exécutées par les services du Dessin, de l'Héliogravure et de la Gravure, et permettre de procéder à un nouveau tirage de la feuille remaniée.

Aussi, s'il n'y a pas urgence, un officier du Service de la cartographie étrangère exécute, au fur et à mesure, ces rectifications ou complétages, sur un exemplaire du dernier tirage. Cet exemplaire est conservé en portefeuille jusqu'au moment où la somme des additions ou rectifications nécessite la préparation d'une édition révisée. Cependant, si une nouvelle ligne ferrée importante est livrée à l'exploitation son tracé est immédiatement donné au Service de la gravure, afin que cette ligne puisse être portée au plus tôt sur la planche de noir.

Si la première édition a dû être faite hâtivement et avec peu de documents, on prépare, au Service de la cartographie étrangère, une seconde minute qui servira à faire ultérieurement une nouvelle feuille. Mais si les événements nécessitent la mise à jour d'une zone déterminée, par un exemple d'un théâtre d'opérations militaires, on porte les additions sur la feuille ou sur les feuilles intéressées et on les remet aux services du Dessin et de la Gravure avant chaque tirage, de façon que les éditions successives portent les modifications signalées.

Avec cette façon de procéder, il arrive un moment où cette révision devient difficile et il est toujours délicat de toucher au fond du figuré du terrain.

Dans ce cas, en même temps qu'il porte sur les feuilles régulières les modifications les plus importantes, le service de la cartographie étrangère établit de toutes pièces des croquis des régions intéressantes, sans s'occuper des coupures des feuilles—Il arrive souvent que l'utilisation d'un document nouveau provoque des modifications sur quatre feuilles jointives. Les dessins établis par les officiers sont aussitôt et directement héliogravés puis tirés en une seule couleur; ils peuvent

ainsi être remis en temps utile aux différents services intéressés à les consulter.

Ces croquis, qui ont été exécutés suivant un ordre d'urgence, sont ensuite soudés les uns aux autres, et leur réunion permet la production d'une carte spéciale; ou bien rapportés sur une feuille de projection, ils servent à dresser une nouvelle minute régulière, que l'on traitera ensuite par les procédés ordinaires dans les conditions normales—et sans hâte, puisque les croquis monochrômes ont été livrés—pour arriver, en dernier lieu, à la publication et à la mise dans le commerce d'une feuille en couleurs destinée à remplacer l'édition précédente.

À titre d'exemple, nous citerons quelques travaux exécutés dans ce sens pendant les dernières années:

La feuille de Nankin fut publiée en mai 1899. Dès 1902 des documents nouveaux permirent de préparer une nouvelle minute plus complète, surtout dans la partie méridionale, et en septembre 1904 parut une seconde édition.

Au moment où les nouveaux exemplaires étaient publiés, paraissait la relation d'un voyage à travers le Chan-Toung et le nord du Kian-Sou, accompagnée d'un croquis. L'itinéraire suivi porte sur les feuilles de Pékin et de Nankin, et il y a de notables différences, principalement dans le figuré du terrain, entre nos cartes au 1,000,000^e et le croquis de la zone parcourue par l'explorateur dans l'hiver de 1902–3.

Aussi, le Service de la cartographie étrangère prépare-t-il, dès maintenant, une réfection de la partie nord de la feuille de Nankin qui était publiée et une réfection de la partie sud de la feuille de Pékin, laquelle, depuis sa première édition, en mai 1899, avait été complétée en deux révisions successives par l'utilisation de cartes à grande échelle de la concession anglaise de Wei-hai-Wei, de la concession allemande de Kiao-Tchéou et du tracé du chemin de fer du Chang-Toung, de Tsin-Tao à Tsi-Nan Fou.

Les feuilles de Moukden, Vladivostok, Seoul, Kang-Neung, Quelpaert et Nagasaki avaient été publiées en 1899 et 1900. Pour leur établissement, on s'était servi principalement de la carte russe au 1,680,000^e, que l'on avait complétée en utilisant quelques travaux de missionnaires et surtout les itinéraires de l'attaché militaire français à Pékin. Postérieurement à la publication de ces feuilles, le Service géographique avait reçu de nouveaux documents, presque tous d'origine japonaise; aussi le Service de la cartographie étrangère avait-il préparé une révision, ce qui lui permit, au mois de janvier 1904, lors de la tension politique entre la Russie et le Japon, de remettre aux services du Dessin et de la Gravure des exemplaires partiellement révisés.

Dans les premiers jours de février 1904, lorsque les hostilités commencèrent, les feuilles révisées furent livrées au commerce. D'importantes modifications avaient été faites, principalement sur les feuilles intéressant la Corée; la côte méridionale, sur le détroit de

Corée, avait dû être refaite entièrement et la montagne, qui avait été exagérée dans la première édition, avaint dû être réduite dans de fortes proportions. Quant au chemin de fer de Fou-San à Séoul, il ne fut possible de le tracer exactement qu'à une troisième révision, en mars, avec des documents émanants des ingénieurs japonais construisant cette voie ferrée et rapportés par un officier français revenant de Corée.

En même temps que se poursuivaient ces rectifications et ces additions successives, le Service de la cartographie étrangère exécutait une carte spéciale de Corée (en deux feuilles, au 1,000,000^e, portant le titre de "Carte provisoire de la Corée"), en utilisant des documents japonais plus précis et plus complets dont la traduction fut faite par un lettré coréen. Il était impossible, en effet, de pousser la révision des six feuilles régulières plus loin qu'elle avait été faite. Eût-il été d'ailleurs possible de la faire entreprendre par les officiers du Service de la cartographie étrangère, que les services du Dessin et de la Gravure n'auraient pu terminer en temps utile leurs travaux spéciaux.

La minute de cette carte provisoire fut entièrement terminée, planimétrie et montagne, à la fin de mars; elle fut aussitôt héliogravée, puis tirée en trois couleurs et remise aux services intéressés; elle ne fut pas livrée au commerce.

Actuellement, on la complète à l'aide de documents nouveaux; elle servira ultérieurement à refaire entièrement les six feuilles énoncées plus haut.

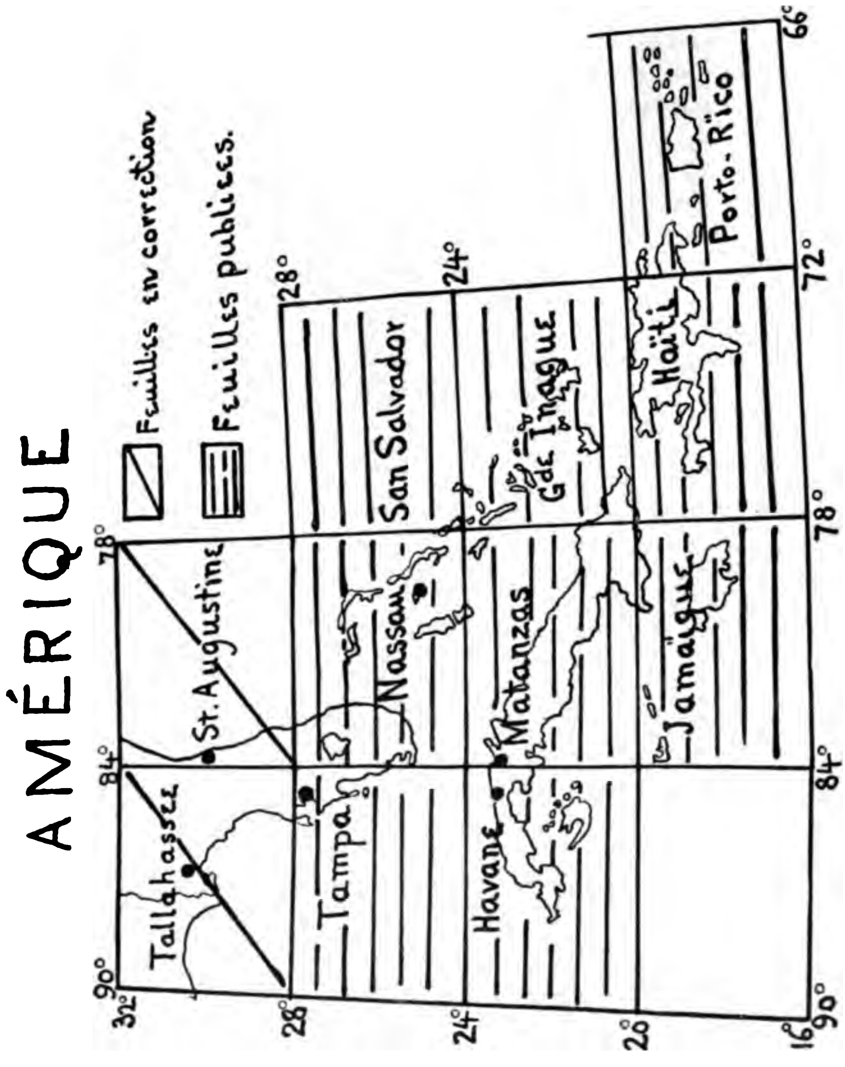
Cette carte provisoire répondait à des besoins spéciaux; on pouvait supposer que d'importants événements militaires se produiraient en Corée. Mais, dès le passage du Yalou par les Japonais, le 1er mai, l'intérêt se trouvait déplacé, les opérations stratégiques et tactiqnes devant se dérouler en Mandchourie. Les documents parvenus depuis peu de temps au Service géographique permettaient de compléter la zone probable des futures opérations. Mais cette zone portait sur quatre feuilles: Moukden, Tcheng-Te-Fou, Pékin et Séoul. Le fond de ces feuilles était lui-même à reprendre. Étant donné l'urgence, il devenait préférable de dresser une feuille spéciale. Il y a lieu de remarquer, en outre, que les coordonnées géographiques de Moukden, point central du groupement, diffèrent sensiblement sur les divers documents officiels russes (14′ 14″ de différence dans la longitude, soit 18.5 millimètres d'écart à l'échelle du 1,000,000^e); les raccords des feuilles rectifiées, en tenant compte du déplacement de Moukden, devenaient impossibles avec les anciennes feuilles.

On établit donc de toutes pièces une feuille spéciale dite du "Théâtre des opérations en Mandchourie," au 1,000,000^e, en opérant par croquis successifs.

On dressa d'abord un croquis de la région entre Eui-Tjyou (Yalou) et Liao-Yang; puis un croquis de la presqu'île de Liao-Toung (Port-

Arthur); enfin, un croquis de la région au nord des deux précédentes (Moukden).

Ces trois croquis partiels, exécutés en une semaine (mai 1904), au Service de la cartographie étrangère, furent réunis en un croquis général qui put être héliogravé dans les premiers jours de juin et remis immédiatement aux bureaux du Ministère. Le Service du dessin put



alors reprendre le travail, et une édition fut livrée au commerce dans les derniers jours du mois d'août.

Cette carte spéciale, ainsi que la carte provisoire de la Corée, dont nous avons parlé plus haut, seront utilisées pour la réfection intégrale des feuilles régulières.

CARTE D'AMERIQUE

Cette carte a été commencée en mai 1898, au moment de la guerre de Cuba. Neuf feuilles étaient terminées en 1899: Tampa, Nassau, San Salvador, La Havane, Matanzas, Grande Inague, Jamaïque, Haïti et Porto-Rico.

Deux feuilles commencées (Tallahassee et Saint-Augustine) ont été interrompues faute de documents pour les compléter. (Voir le tableau d'assemblage No. 4.)

Les cartes et ouvrages qui ont servi sont les suivants:

Île de Cuba.—"Mapa de la isla de Cuba," au 500,000^e, d'après le Dépôt de la guerre espagnol.

Île de Saint-Domingue.—Carte extraite des "Mitteilungen" de Petermann, année 1874, rectifiée en 1901 par la carte de Dantes Fortunat, au 800,000^e.

Jamaïque.—Carte anglaise au 418,716^e, éditée par la maison Edward Stanford de Londres.

Île de Porto-Rico.—Carte espagnole au 1,000,000^e; carte espagnole au 100,000^e de la Compañía de los ferrocarriles de Puerto Rico.

Floride.—Carte américaine au 720,000^e, des Ingénieurs topographes, et atlas de poche (Géorgie, Floride et Alabama) au 1,000,000^e, de la maison Rand, McNally & Co., de Chicago.

Côte et petites îles.—Cartes marines de France.

Plans et environs de villes.—Géographie de Reclus.

Les dessinateurs ont ramené à l'échelle du 800,000^e, au moyen du pantographe, les cartes originales, et leurs dessins ont été exécutés à cette échelle, pour être réduits par la photographie et héliogravés sur zinc, au 1,000,000^e.

NOTE ON THE MAP OF AFRICA ON THE SCALE OF 1:1,000,000, PUBLISHED BY THE INTELLIGENCE DIVISION OF THE WAR OFFICE, LONDON

By Maj. E. H. HILLS, C. M. G., R. E., Chief of the Topographical Section, General Staff

The production of a map of the whole of Africa upon the uniform scale of 1:1,000,000 was initiated in the year 1900, the first sheets being published in 1901.

Since then publication has proceeded steadily. At the present time (November, 1904) 18 sheets are issued and 20 more are in an advanced state. It is hoped that in the immediate future new sheets will appear at the rate of about 12 yearly.

The map corresponds in a general way to the map of the world proposed by the International Geographical Congress at Berne.

The sheets are 6° in longitude by 4° in latitude, or about 25 by 17 inches inside the marginal lines, a convenient size for printing and handling.

The scale is given both in the metric measure and in miles to the inch.

Each sheet is separately projected. The system of projection is a conventional one wherein the four bounding lines of the sheet are straight and are the requisite fraction of the length of the line measured on the earth's surface. All parallels and meridians are therefore straight lines and no four sheets will exactly fit together, though the error in fitting is very small until comparatively high latitudes are reached.

Up to about 30° latitude this projection is a good one; above that the error in azimuth at the corners, owing to the oblique intersection of parallels and meridians, becomes marked. It would not be a suitable projection for a map of Asia nor for one of North or South America.

The map is printed in three colors: Black for the names and detail, blue for water, including names of rivers, lakes, etc., and brown for the hills. The latter are represented by form lines or rough, broken contours; heights, where known, are inserted.

The mass of material used in the compilation of this map is so great that it has not been found practicable to include any note on the sheets giving the sources of information. Some of the sheets represent the putting together of more than 100 separate maps, plans, route sketches, and other fragmentary material.

The sheets are issued in two forms, provisional issues without hills, and final issues. The whole map is kept constantly under revision, and new editions of all sheets comprising unsurveyed and partially explored regions will be issued as fresh information becomes available.

SUR L'APPLICATION DU SYSTÈME DÉCIMAL À LA MESURE DE L'ANGLE

Par M. LACOUR, délégué du Yacht Club de Paris et M. de REY PAILHADE, délégué de la Société de Géographié de Toulouse

À la veille du jour où les États-Unis et l'Angleterre vont adopter le système métrique des poids et mesures, il me paraît utile de rappeler que les congrès de Londres (1895) et de Berlin (1899) ont invité les géographes à étudier l'application du système décimal à la mesure de l'angle.

On sait, par de nombreuses expériences exécutées avec soin, que la division décimale du quart de cercle en 100 grades est très avantageuse pour la géodésie, la cartographie et la navigation. Les instituts géodésiques des Etats suivants ont adopté officiellement cette méthode, afin de pouvoir en profiter: Belgique, Bade, Würtemberg, Roumanie, Serbie, Turquie, Japon, Chile et République Argentine. L'emploi du grade ou centième partie du quart de cercle est déjà obligatoire dans la plupart des administrations publiques françaises. Il est éxigé pour les examens des écoles polytechniques, Saint Cyr, Forestière, Institut agronomique; pour les divers baccalauréats et l'agrégation des lycées de jeunes filles.

Cette unité angulaire relie étroitement les angles aux longueurs; en effet, au niveau moyen des mers de la terre, la longueur d'un centi grade-arc est égale à 1 kilomètre. Cette équivalence du kilomètre et du centigrade-arc qui est commode pour les calculs et la mémoire, fera disparaître le mille marin, que n'est pas compréhensible pour tout le monde. La mesure de longueur en terre et sur mer sera invariablemente le kilomètre.

Le service géographique de l'armée française emploie exclusivement le grade depuis plus de cinquante ans; les nouvelles cartes publiées par ses soins ne portent plus de graduations supplémentaires en degré sur le bord de la feuille.

Afin de simplifier le plus possible les calculs, les horlogers de la marine ont créé un type de chronomètre décimal dit tropomètre,[a] qui

[a] On pourra voir des tropometres a l'exhibition de Saint-Louis, chez Monsieur Leroy, horloger de la marine à Paris.

divise le quart de jour en 100 grades-temps. On évite ainsi toute transformation du temps en angle et inversement. C'est une méthode très supérieure à celle des heures et des degrés. On diminue ainsi de près d'un tiers la durée des calculs, et le taux des erreurs tombe de 4 à 1; la fatigue cérébrale des calculateurs est amoindrie et l'on peut se servir directement des machines à calculer.

Les constructeurs d'instruments de précision fournissent d'excellents cercles gradués en grades sans augmentation de prix.

Ces avantages considérables ont décidé quelques observatoires à se munir d'appareils décimaux, notamment l'Observatoire d'Abadia, près Hendaye (France), créé par le célèbre voyageur M. d'Abadie, et celui de Mustapha Supérieur, près Alger, installé par M. A. Jouffray, astronome.

On possède tous les livres nécessaires aux calculs géodésiques et nautiques, les publications des tables trigonométriques décimales se sont multipliées en France sous des formes très diverses.

MM. de Rey Pailhade et Jouffray viennent de poser la clef de voûte de cet édifice en publiant les éphémérides décimales pour 1905 (Paris, Gauthier-Villars) qui ont reçu le meilleur accueil des savants du monde entier, comme le prouvent les noms des souscripteurs de la première heure.

Les géodésiens, les navigateurs, les astronomes et les géographes cartographes pourront faire directement tous leurs calculs suivant les simples règles du calcul décimal, sans avoir jamais besoin de faire une réduction.

Tous les calculs nautiques pratiques pourront être éxécutés par des auxiliaires d'une instruction très élémentaire, ne sachant que les quatre règles de l'arithmétique.

L'adoption du système métrique des poids et mesures, par toutes les nations civilisées démontre la supériorité de la méthode décimale sur les anciennes mesures n'ayant pas entre elles des rapports en harmonie avec la numération parlée et écrite.

L'application du système décimal à la mesure du temps et de l'angle rendra à la science d'aussi grands services que le système métrique des poids et mesures en a déjà rendu au commerce et aux sciences exactes. Il convient donc de faire connaître ces avantages à tout le monde dès maintenant.

On trouve sur beaucoup de cartes deux graduations juxtaposées en degrés et en grades. Parmi les plus connues, je cite celle de la Suisse au 1/200,000; la carte de l'Institut cartographique militaire de la Belgique au 1/20,000; la carte de l'État-major français au 1/80,000 porte la graduation en degrés à l'extérieur.[a]

[a] La graduation supplémentaire indique des divisions décimales du quart de cercle, le grade (GR) la centième partie du quart de cercle; le centigrade indiqué par le signe (`) est la centième partie du grade et vaut 1 kilomètre sur un arc de grand cercle.

Nous proposons donc que "le Congrès: 1°, invite les cartographes à mettre sur leurs nouvelles cartes une graduation supplémentaire dans la division décimale du quart de cercle avec une légende explicative;[a] 2° exprime le désir de voir donner les notions de la division décimale du quart de cercle dans les établissements d'enseignement secondaire et supérieur."

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[a] Un cartographe français, M. Hérisson, avait déjà publié en 1821 une carte politique de l'Europe sur laquelle figurent les deux graduations. Il est très regrettable que son exemple n'ait pas été suivi.

LA CARTE DE LA RUSSIE D'EUROPE, EN 16 FEUILLES, À L'ÉCHELLE DE 1 : 2,000,000

Par Col. J. de SCHOKALSKY

Jusqu'au dernier temps la Russie ne possédait un atlas de géographie universelle comme il en existe en Allemagne, en Angleterre, en France; on se contentait des éditions étrangères.

Un des grands éditeurs de Saint-Pétersbourg, M. A. Mares, fit une tentative pour remédier à cet état de choses, et il y a huit ans entra en pourparler avec la maison bien connue de Leipzig, "Wagner et Debes," avec l'intention de publier une traduction de leur atlas en langue russe. Le choix des cartes, la traduction des noms géographiques, etc., furent faits par le professeur de géographie à l'Université de Saint-Pétersbourg, M. Pétrie.

À cette occasion plusieurs cartes reçurent des corrections importantes, mais pour être vraiment un atlas russe il lui manquait des cartes de l'Empire de la Russie à une échelle suffisante. Après une délibération on s'arrêta, entre autres, sur une carte de la Russie d'Europe à l'echelle de 1:2,000,000 en 16 feuilles qui ferait partie de l'atlas. Comme base on choisit la carte d'État-major à l'échelle de 1:420,000, et on en fit la gravure sur pierre à Saint-Pétersbourg dans les ateliers de M. A. Mares.

À peine les épreuves du noir étaient-elles achevées que M. le professeur Pétrie mourut. Alors M. Mares proposa à M. le colonel J. de Schokalsky, adjoint au président de le section physique de la Société impériale russe de géographie, de prendre sur lui la besogne de la rédaction de la susdite carte.

Comme il a été dit plus haut, la base de la carte était celle de l'Etat-major au 1:420,000, à laquelle on ajouta: les lignes des chemins de fer nouvellement construites, les lignes de télégraphes, les stations des chemins de fer et les noms des bureaux de poste et de télégraphe, des chemins postaux, etc. Mais tous les renseignements qui devaient figurer sur la carte en couleurs n'étaient point représentés et même les pierres qui devaient les porter n'étaient pas entamées.

Actuellement la carte est presque finie; il ne reste qu'à achever la feuille du Caucase.

Premièrement M. de Schokalsky revisa l'inscription de tous les lieux habités en se fondant sur les données du récensement de l'Empire en 1897, qui viennent seulement d'être publiées et pas toutes encore (sur la carte la population d'un lieu est indiquée par le genre de l'écriture). Puis il ajouta sur plusieurs feuilles, surtout sur celles de la rangée nord, quantité d'itinéraires des voyageurs à travers cette partie de l'Empire qui n'a jamais été levée régulièrement. Quelques-uns de ces itinéraires sont encore inédits, par exemple le tracé de la rivière de l'Obi, faite par l'éxpédition du colonel de Vilkitski (il est aisé de voir la quantité des données tracées sur la carte par une comparaison des feuilles No. 4 avant la révision de M. de Schokalsky et après).

Tous les grands lacs portent le chiffre indiquant la hauteur de leurs niveaux au dessus de l'océan, ainsi que de sa profondeur si cette dernière est connue, ainsi que les isobathes.

Il a été ajouté quantité de chiffres indiquant la hauteur en mètres des points saillants. Aux autres indications on ajouta encore les lignes des téléphones et les emplacements des courortes; 59 signes différents sont employés pour indiquer les différentes données figurant sur la carte.

Les isobathes de la mer Noire et surtout de la mer Caspienne furent complètement refaites.

Pour la mise à jour de la carte on a consulté plus de 200 ouvrages statistiques et géographiques et une quantité de cartes en partie manuscrites.

Voilà pourquoi on peut dire que la carte présente, avec tous ses défauts que ne peut éviter aucune œuvre humaine, est pour le moment la carte la mieux mise à jour.

MARINE HYDROGRAPHIC SURVEYS OF THE COASTS OF THE WORLD

By GEORGE W. LITTLEHALES, U. S. Coast and Geodetic Survey

The accumulated stock of marine hydrographic knowledge in its availibility for the construction of navigational charts of the coasts of the world is divided into four classes for the purposes of this communication. Upon the accompanying world chart the extent of coast line comprised within each of these four classes is indicated by appropriate symbols depicting the coasts that are completely surveyed, those that are incompletely but serviceably surveyed for purposes of navigation, those that are explored for purposes of navigation, and those that are unexplored for purposes of navigation.

It should be made clear with reference to those coasts which are classed as being completely surveyed that, excepting in rare instances, no greater completeness has been attained in the portrayal of the forms and characteristics of the strip of the sea bottom which borders the coast than is yielded by measurements obtained by dropping a sounding plummet at close intervals, and that nearly all coasts and harbors, whatever may be the initial completeness of the surveys, require reexamination in the course of time to disclose the altered conditions that are produced by natural agencies and artificial developments.

It will not escape attention that while there is a comparatively small total extent of completely surveyed coast which bounds the world's seats of enlightenment and wealth in the Northern Hemisphere, the extent of coast that is unexplored for purposes of navigation is yet smaller and is almost confined to the frozen regions of the earth, which are unpeopled and unvisited by commerce. A prominent feature of the investigation and one which can not fail to bring a realization of the great responsibility resting upon navigators and the skill and caution required of them in the navigation of coastal waters in nearly all parts of the world, is the immense extent of the coast line which, while sufficiently known to be approached, can not be navigated with security.

It is in general useless for the nautical surveyor of the present day to devote himself to the rapid reconnaissance of a coast in the manner

that proved so acceptable in the middle of the last century, for such a survey would not now prove beneficial with reference to any but the unexplored regions.

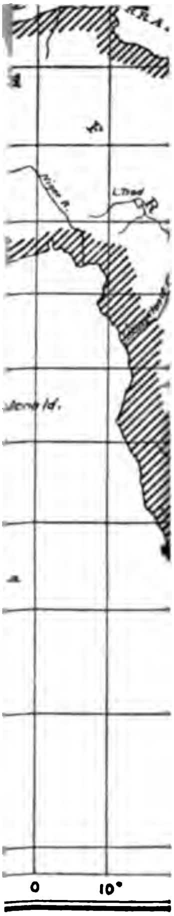
The parts of the world that have been completely surveyed and the parts about which, from the standpoint of the marine hydrographer, nothing is known, are equally beyond our concern at present, for on the one hand the needs of commerce and navigation have been met and on the other hand commerce and navigation have as yet no needs. It is to the vast extent of the coasts of the world concerning which marine hydrographic knowledge exists in varying degrees of incompleteness that we should address ourselves, with a view of directing attention to the faults which may be corrected and to the wants which may be supplied.

On leaving our own completely surveyed Atlantic seaboard, we come at once, among the oldest colonies in the Western Hemisphere and in a sea of great present and prospective importance, upon coasts concerning which there is no adequate information for the construction of charts and the guidance of shipping. The coasts of the island of Haiti, outside of the more important ports and harbors, are very imperfectly charted. Our knowledge of the harbors of Cuba has been lately much improved, but the sections of coast connecting these harbors are not yet well represented. No better portrayal of the north coast of South America from Panama to Trinidad has ever been afforded than that which resulted from a cursory examination made in the early part of the last century. There are doubtless many places along this coast where future surveying operations will develop useful anchorages for the improvement of commerce and the safety of vessels. The ports leading to many of the important maritime centers of Brazil have been efficiently surveyed, but the general approaches to the coast are not completely developed. In the Rio de la Plata navigation has been rendered fairly safe, but of the intervening coast, until the Strait of Magellan is reached, it may only be said that, beyond several isolated local surveys lately executed by the Argentine Government, nothing has been done since the general examination in 1830. The efforts of British and Chilean hydrographic surveyors have effected much improvement during the last generation in the charts of the Strait of Magellan and throughout the waters of Chile, although the whole labyrinth of channels in southern Chile is still inadequately known for the purposes of the many steamers that are continually passing through; and with reference to the entire western coast of South America, the efficient surveying operations have clustered around local developments that were taking place here and there, leaving no general survey of the whole coast by which it can be laid down in sufficient detail.

The surveys of the immediate approaches to Panama, although imperfect, are serviceable; and the same may be said of the Central American and Mexican coasts which connect the Republic of Panama with the completely surveyed Pacific coast of the United States. Of the coastal waters in the northeastern Pacific much more is known in relation to the waters of the British dominions than with reference to the Alaskan coasts. Indeed the marine hydrographic surveys of Alaska are as yet very incomplete, especially in the Aleutian Islands, where many coasts remain barely explored. Russian Siberia and Korea have for the most part only been hydrographically explored; but nearly all of the coasts of the Empire of Japan have been completely surveyed and charted, and the coasts of China, together with the China Sea, where British surveying ships have worked continuously for fifty years to put in their right positions the multitude of rocks and shoals which encumber this region, are now well known. Much, however, yet remains to be done on the eastern and southern confines of this sea. Only the most important harbors and sections of coast in the Philippines and the Dutch East Indies have been well charted. Parts of Tonkin and the southern, and especially the eastern, passages into the China Sea need much additional examination in detail. Australia and New Zealand are enveloped with good nautical charts, which are constantly being amended as new developments give rise to increased needs for more detailed surveys, and most of the important harbors and the thickly inhabited maritime sections have been quite completely done. The Coral Sea, or what is termed the outer passage between Australia and the Indian Ocean, is now much improved beyond its former state, owing to the necessity of providing more direct routes than those which were formerly followed, and most of its dangerous reefs are now set down in the charts. British India is better surveyed than many other parts of the best known coasts of the world, and the shores of the Red Sea and the Mediterranean have been minutely surveyed excepting in a few parts where minor details are not now important.

Of the coast of Africa, aside from that portion which fronts on the Red Sea and the Mediterranean, the most vaguely charted portion is that of Somaliland, and the most completely charted parts are embraced in that well-surveyed section, including Madagascar, which extends southward from Zanzibar around the Cape of Good Hope to the regions of Table Bay. The whole of the west coast can now be laid down with closeness to its true position on the face of the globe, and while some parts of it have been merely explored by the nautical surveyor, many other parts are better known, and some of the harbors and off-lying islands have been surveyed with considerable approach to completeness.

The coasts of Europe, excepting the Spanish Peninsula and those parts bordering on the Arctic Ocean, are completely surveyed, and an



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important center of activity in marine hydrography has for many years existed in Great Britain, resulting not only in elaborate surveys of the waters of Great Britain and Ireland, but in meeting the demand for reliable nautical charts in every part of the British Empire and in whatever other parts of the world British trade has been active or springing up.

Nearly a century has now elapsed since the close of the era of discoveries among the vast groups of islands and coral reefs with which the immense area of the Pacific Ocean is studded, and the chaotic state of geography at that time, in which it was sometimes impossible for discoverers to return to the islands discovered, has given place to a state of order at the present day. The ships of all the great maritime nations have contributed in a greater or less degree to this advance by fixing the correct geographical positions of individual islands, by surveying harbors and anchorages in the various groups, and by disproving the existence of many supposed rocks and dangers which were set down in the older charts from reports of former navigators, often doubtless based upon misleading appearances of the sea.

But important as is the surveying work that has already been accomplished in the Pacific, it is only the beginning of that which is to come. There is scarcely an island group in the whole of Oceania that is completely charted. The great work that remains to be done here ought to progress more rapidly in the future, since all these lands have at length been parceled out among leading nations of the world.

SUR LES ORIGINES DE L'ART DE LEVER LES PLANS À L'AIDE DE LA PHOTOGRAPHIE

Par M. le colonel A. LAUSSEDAT, Membre de l'Académie des sciences de Paris

Au mois de juillet 1839, étant élève à l'École polytechnique, j'avais eu l'occasion, avec deux de mes camarades, d'aller à l'Observatoire de Paris, la veille même du jour où Arago devait présenter à l'Académie des sciences son rapport sur la merveilleuse découverte de Daguerre. Avec sa bienveillance accoutumée, pour des jeunes gens qu 'il traitait en camarade, le grand physicien nous montrait les premières épreuves de daguerréotype, parmi lesquelles une vue des Tuileries prise du quai Voltaire (que l'on voit aujourd'hui dans les vitrines du Conservatoire des arts et métiers), où il nous faisait remarquer avec quelle facilité on pouvait relever tous les détails de l'architecture extérieure de l'édifice, à une échelle déterminée. Eh bien! ajoutait-il, je pense que vous pourrez également vous servir plus tard de semblables images pour étudier et relever les accidents du terrain, en un mot, pour lever les plans topographiques.

Cette idée, qui m'avait beaucoup frappé, aurait pu cependant s'effacer de ma mémoire si quelques années plus tard, en 1846, je n'avais pas été chargé de reconnaissances étendues sur la frontière des Pyrénées et de l'étude détaillée d'une position militaire, à Cambo, localité remarquable située sur la Nive, à 20 kilomètres en amont de Bayonne.

Or précisément, cette même année 1846 Arago publiait dans l'Annuaire du Bureau dés longitudes une notice renfermant un conseil qui venait tout-à-fait à propos et que j'essayai de suivre sans en tirer tout d'abord le parti que j'avais espéré.

Cette notice était la reproduction d'un rapport, fait en commun avec l'illustre Beautemps-Beaupré, sur un voyage en Abyssinie de deux officiers d'Etat-major, MM. Gulinier et Ferres, et le conseil auquel je viens de faire allusion était même plutôt une recommandation des plus expresses faite aux voyageurs, et qui s'adressait aussi bien à tous ceux qui ont à exécuter des reconnaissances rapides, de fixer leurs souvenirs en dessinant des vues de paysages qui évitent les erreurs d'une

appréciation hâtive et celles qui sont trop souvent occasionnées par les renseignements vagues des guides.

Beautemps-Beaupré avait d'ailleurs prêché d'exemple en se servant de vues pittoresques, prises à bord d'un bâtiment ou d'une embarcation, pour lever les plans d'îles et de côtes, en même temps qu'il opérait les sondages à de nombreuses stations. Ces vues étaient dessinées à main levée, mais ratifiées et bridées selon l'expression consacrée par des mesures d'angles faites à l'aide du cercle de réflexion de Borda entre des points remarquables plus ou moins nombreux de la côte représentés sur les croquis des vues.

Les résultats vraiment surprenants par leur exactitude des premiers essais de l'inventeur, obtenus en 1793 et 1794, pendant un voyage entrepris par D'Entrecasteaux à la recherche de La Pérouse, avaient été publiés en 1802 et en 1811 dans un petit traité, qui n'en est pas moins une œuvre fondamentale, et les plus incrédules avaient été aussitôt convaincus de la supériorité de la nouvelle méthode sur toutes celles que l'on employait auparavant dans le même but. On sait que les anglais n'ont pas hésité, depuis ce temps, à qualifier Beautemps-Beaupré du nom de père de l'hydrographie.

C'est cette méthode que j'essayai, dès 1846, en même temps que le colonel du génie Leblanc, d'appliquer à terre pour relever plus ou moins complètement les détails topographiques, principalement en pays de montagnes. Mais je n'y réussissais qu'à moitié, les dessins à main levée étant toujours longs à exécuter, incomplets et souvent inexacts, malgré le soin que l'on prenait, pour brider les erreurs, de mesurer ou simplement d'évaluer quelques angles que l'on inscrivait sur les croquis de vues et dont on tenait compte dans une mise au net plus précise. Il ne s'agissait plus, en effet, dans ce cas, des contours tout au plus ondulés d'une côte, généralement faciles à représenter sur une vue, mais d'un ensemble d'objets situés à des distances très différentes, et à mesure qu'ils s'éloignaient, leur détermination devenait plus indécise. C'est alors que je me rappelai la conversation de 1839 à l'Observatoire.

Cependant la photographie, à cette époque, était encore d'un emploi bien délicat et les images formés à travers les objectifs n'étaient pas à l'abri des déformations, à moins de se contenter d'un champ très limité. Je songeai alors à recourir à la chambre claire de Wollaston dont je m'étais servi accidentellement quelques années auparavant. Cet instrument donnait en effet des images sans déformation et offrait un champ utilisable de 60° au moins à la distance de la vue distincte de 0.30 mètres environ, très convenable sous tous les rapports. Ces conditions étaient donc excellentes pour appliquer la méthode de Beautemps-Beaupré. Toutefois les images virtuelles, comme on sait, projetées sur une planche à dessiner n'étaient pas sans présenter un assez grave inconvénient; elles se déplaçaient au moindre mouvement de la

tête de l'observateur; il y avait une parallaxe plus ou moins bien corrigée, à la vérité, d'après les indications de Wollaston lui-même, mais pas assez rigoureusement pour le but que je me proposais d'atteindre. Il fallut donc trouver le moyen de supprimer complètement cette parallaxe, c'est-à-dire de rendre l'image immobile sans d'ailleurs l'altérer. J'y parvins, et avec un appareil construit avec le plus grand soin par l'excellent artiste G. Froment, d'après mes indications, je me trouvai en état d'étudier à l'aise les détails de la méthode et de donner les règles à suivre pour tirer le meilleur parti des vues rigoureuses dessinées rapidement de différentes stations, d'abord pour tracer le plan des détails du terrain représentés sur les paysages, puis les courbes de niveau destinées à figurer le relief de ce terrain.

Dès 1850, de nombreuses expériences étaient entreprises aux environs de Paris et il en est quelques-unes qui, publiées de 1854 à 1861, sont devenues en quelque sorte classiques, comme le plan d'une partie de la forteresse du mont Valérien et celui de l'un des fronts du fort de Vincennes.

Le Service du génie auquel j'avais l'honneur d'appartenir s'intéressait beaucoup à ces expériences que les maréchaux Vaillant et Niel prirent successivement sous leur patronage.

En 1859 le comité des fortifications m'accordait le crédit nécessaire pour faire l'acquisition d'une chambre noire munie d'un niveau à bulle d'air et d'un trépied à vis calantes pour me permettre de prendre des vues photographiées dans les conditions convenables et de les substituer, dans la mesure du possible, aux vues dessinées à la chambre claire. J'allais alors demander conseil à mon ancien maître et ami, le savant physicien Regnault, sur les procédés photographiques à employer. On en était alors aux [illegible] et les essais que nous faisions, sur la terrasse du Collège de France, étaient encore si inégaux que Regnault lui-même m'engageait à attendre et à continuer à me servir de la chambre claire dont il avait été l'un des premiers à approuver [illegible] que j'y avais [illegible] et qui en faisaient un instrument [illegible] grande simplicité.

[illegible] à l'Observatoire [illegible] je montrais aussi à Arago [illegible] de la France [illegible]. Malgré le danger dont il était déjà menacé de perdre [illegible] s'intéresser à des [illegible] de reconnaître [illegible] mes dessins et, tout en m'engageant à [illegible] ne manquait pas de me répéter qu'il [illegible] fallait pas [illegible] les progrès de la photographie pour les mettre à profit le plus tôt possible.

C'était [illegible] tentatives dont [illegible] en 1859, par le célèbre artiste Brunner, une chambre noire montée dans les

mêmes conditions que les instruments de géodésie avec niveau, trépied à vis calantes comme le premier, mais en outre avec un cercle azimutal et un cercle vertical autour de l'arc duquel je mouvais une lunette, en un mot l'instrument que l'on a appelé depuis un photothéodolite.

La même année, 1859, je présentais à l'Académie des Sciences un mémoire sur cette question des levers de plans à l'aide de la photographie et les deux commissaires nommés pour l'examiner, MM. Daussy et Laugier, me demandaient de faire une expérience sous leurs yeux. Cette expérience devant être entreprise dans Paris même, d'accord avec mes juges deux stations furent choisies: la première sur l'une des tours de Saint-Sulpice et l'autre sur la terrasse du petit observatoire de l'École polytechnique.

Pour entrer dans d'autres details, je dirai qu'en dépit d'un temps peu favorable, les vues prises de ces deux points, éloignés de 1,233 mètres l'un de l'autre suffirent pour permettre de déterminer les positions de tous les monuments remarquables que me désignèrent les commissaires avec une exactitude telle que les points demandés, tracés sur une feuille de papier à calquer, à l'échelle de $\frac{1}{6667}$ qui était celle d'un plan de Paris apporté par M. Daussy, coïncidèrent exactement avec leurs correspondants sur ce plan quand les commissaires opérèrent la superposition du calque et du plan, en commençant par les deux extrémités de la base.

En fait de nivellement, ceux-ci se contentèrent de me faire évaluer la hauteur de la flèche de Notre-Dame au dessus de la ligne de faîte de la charpente de la nef, et l'approximation avec laquelle je la déterminai immédiatement leur parut satisfaisante (la hauteur exacte leur avait été indiquée par l'architecte Viollet-Leduc).

Je ne saurais mieux faire pour éviter de trop longues explications que de renvoyer au rapport de M. Laugier publié dans les Comptes rendus des séances de l'académie des sciences, rapport dont les conclusions tout-à-fait favorables furent approuvés par l'Académie.[a]

Toutes ces recherches, je l'ai déjà dit, étaient privées et encouragées par le Comité des fortifications et en 1861, sur sa proposition, le Ministre de la Guerre m'invitait à exécuter un lever détaillé d'une certaine étendue devant un groupe d'officiers de la Division du génie de la Garde impériale.

La localité choisie en terrain assez accidenté était le village de Buc et ses environs, dans le voisinage de Versailles. Les opérations sur le terrain, comprenant la mesure d'une base de 334.80 mètres et celle des angles nécessaires pour déterminer en tout quatre stations d'où furent prises huit photographies, deux à chaque station, durèrent deux heures et demie, et trois jours plus tard je remettais le plan du village, des jardins et des champs qui l'environnent, à l'échelle de $\frac{1}{1000}$, avec des

[a] Rapports sur un mémoire de M. Laussedat, etc., Comptes rendus des séances de l'Académie des sciences, tome I, janvier-juin 1860, p. 1127 et suivantes.

courbes de niveau étagées de mètre en mètre, au commandant de la division, qui l'ayant fait vérifier, demandait aussitôt au Ministre de se servir de la méthode pour effectuer la reconnaissance de la forteresse du mont Valérien devant laquelle il devait faire un simulacre de siège l'année suivante. L'officier, excellent photographe, qui fut chargé de cette reconnaissance, M. le lieutenant [illegible], l'exécuta avec le plus grand succès, beaucoup plus complètement qu'on eût pu le faire par les anciens procédés et, sur le rapport du lieutenant colonel Blondeau, commandant de la Division du génie de la garde, le ministre décidait en 1863 la création d'une petite brigade phototopographique à la tête de laquelle fut placé M. le capitaine du génie Javary, sous la direction du commandant Laussedat.

Les travaux de cette brigade dont l'ensemble comprend des levers réguliers, à de grandes échelles, et des reconnaissances, à de plus petites échelles, analogues à celles que l'on exécute en campagne (levers itinéraires, explorations des abords d'une place forte, etc.) ont été poursuivis pendant huit années consécutives, de 1863 à 1871, avec un succès croissant et n'ont été interrompus qu'après la guerre franco-allemande, M. le capitaine Javary ayant été appelé à diriger les travaux graphiques à l'Ecole polytechnique et sa brigade dissoute. On trouverait le relevé détaillé et un spécimen des résultats auxquels on était parvenu dans un mémoire de M. Javary inséré au No. 22 du Mémorial de l'officier du génie, année 1870, et dans un ouvrage que j'ai publié récemment.[a]

Dès 1864, à Grenoble et aux environs, les résultats obtenus par cette brigade composée du capitaine Javary, d'un habile dessinateur, le garde du génie Galibardy, et de deux auxiliaires, étaient tellement satisfaisants qu'à ma demande le général Morin[b] voulait bien les mettre sous les yeux de l'Académie des sciences qui y trouvait la justification de ses prévisions en faveur de la méthode.

Tels sont les renseignements que, conformément au titre de cette note, j'ai désiré donner sur la genèse de la métrophotographie. J'espère que l'on me pardonnera la forme un peu trop personnelle peut-être de ma communication. Notre grand chansonnier Béranger a dit, depuis longtemps, qu'il fallait être indulgent pour les vieux soldats qui cherchent à faire valoir leurs états de service. Je suis absolument dans ce cas, je le reconnais, mais j'ai la confiance de n'avoir rien avancé que rigoureusement exact, et c'est là sans doute au moins une circonstance atténuante.

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a Recherches sur les instruments, les méthodes et le dessin topographiques, Paris, Gauthier Villars, 1898, 1901 et 1903.

b Exposé sommaire des résultats obtenus en appliquant la photographie à l'étude du terrain, à Grenoble et aux environs, en août 1864, par M. Laussedat, présenté par M. le général Morin, Comptes rendus des séances de l'Académie des sciences, tome LIX, 1864, p. 995 et suivantes.

Si je ne me suis pas décidé à présenter au congrès un historique de tout ce qui a été fait hors de France, depuis les premiers essais entrepris en Prusse en 1865 jusqu'à l'époque actuelle, c'est que cette note eut dû prendre des proportions démesurées. Je suppose d'ailleurs que la plupart de ses membres n'ignorent pas les principales et brillantes étapes d'un odyssée qui se continue sans relâche. Au surplus, l'honorable A. G. Wheeler que j'ai prié de vouloir bien m'excuser auprès de ses collègues de n'avoir pas cru devoir, à 85 ans, franchir encore une fois l'Atlantique pour m'unir à eux, leur donnera la plus haute idée de l'état de la question en leur présentant, d'une part, les admirables résultats obtenus au Canada depuis 1888, par lui-même et par ses collaborateurs, sous la direction de leur distingué chef, l'arpenteur général M. E. Deville, et en leur signalant ceux que promettent les nouvelles méthodes, fondées sur les propriétés de la stéréotypie, dont de merveilleux spécimens viennent d'être publiés, cette année même, d'abord par M. le docteur C. Pulfrich d'Iéna, l'ingénieux inventeur du stéréo-comparateur, et en tout dernier lieu par le savant colonel Baron von Hübl, de l'Institut militaire géographique de Vienne, qui semble avoir atteint la limite des espérances permises dans cet ordre d'idées.

GEOGRAPHIC WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY

By W. C. HODGKINS and G. R. PUTNAM, U. S. Coast and Geodetic Survey

GENERAL INVESTIGATIONS

According to the classification of topics suggested in the circular of the executive committee of the International Geographic Congress, the geographic work of the Coast and Geodetic Survey falls chiefly in the second, fifth, and sixth divisions, viz, mathematical geography, descriptive geography, and geographic technology, touching the first of these subjects in the astronomic, geodetic, and gravity work; the second in the examinations and detailed surveys of all portions of our coasts, and the third in the charts and other publications of the Survey.

While it rarely happens that the Survey has the opportunity to explore entirely unknown regions, it is not infrequently called upon to examine stretches of coast concerning which the existing information is so meager and sometimes so misleading that a survey amounts to an exploration or almost to a rediscovery. In general, however, the operations of this service consist in the improvement of our knowledge of matters which are already known with some inferior degree of precision and hence must usually lack the novelty and freshness of interest which attach to explorations of hitherto untrodden lands or unknown seas.

This may be illustrated by a reference to the charts of the Philippine Archipelago, the most recent addition to our field of labor. These islands have been known for centuries, and many charts of their coasts have been issued by the Spanish and other governments, but experience has shown that many of these charts are defective or incomplete. To correct these imperfect charts will require a complete survey of the entire coast and of the adjacent waters, a work of enormous magnitude, which will consume much time and will call for large expenditures. Yet, after its completion, when the corrected chart is published, that final summation and fruit of long endeavor would probably impress the casual observer as being no better or more interesting than the old and inaccurate map which it displaces. To adequately appreciate such a result one must possess the local knowl-

edge to apprehend the correct delineation of the natural features and an enlightened faith in the precision of the surveys upon which the chart is based.

But in spite of the lack of startling novelty in its operations, there is much that may well interest geographers in the work of the Coast and Geodetic Survey, not only in its original field of labor, the coasts of the United States as they existed prior to 1867, but in its progressive extension to the subsequently acquired territories of Alaska, Hawaii, Porto Rico, and the Philippine Islands. Based upon a system permitting of indefinite expansion without detriment to the methods or to the quality of the work, these operations have been readily adapted to the wonderfully varied conditions found in different parts of the now vastly extended field, and, so far as the available supply of men and means has permitted, the issue of new and the revision of old charts have kept pace with the constantly increasing demand of navigators.

While the immediate exigencies of a special or local survey demanding the prompt publication of a chart in advance of its exact coordination upon the spheroid may sometimes cause a change in the order of operations, the finished maps of this service are based always upon careful astronomical determinations of latitude, longitude, and azimuth, the various astronomical stations being rigidly connected by suitable systems of triangulation, which at the same time furnish the numerous determinations of position needed for the topographic and hydrographic surveys which directly supply the material for the construction of the charts.

Other classes of observations serve to complete the work. Tidal observations furnish data for reducing the soundings to a uniform datum surface or "plane of reference" and for predicting the times and heights of the tides on future dates. Magnetic observations determine the declination of the needle or "variation of the compass" for the use of navigators and land surveyors, and the dip of the needle and the total magnetic intensity for use in the study of the laws of terrestrial magnetism. This subject, which is constantly becoming more important, receives the attention of a special division of the organization. Pendulum observations determine the force of gravity and thus add to our knowledge of the figure of the earth.

Recent developments in the methods of base measurement, triangulation, leveling, and magnetic observations are described in special papers and will not, therefore, be discussed here, though it may be well to mention a striking feature of the recent magnetic work of the Survey, the installation upon some of the ships of the service of apparatus for making complete magnetic stations at sea. Observations made in the course of voyages to Porto Rico and in trips along our coast have given excellent results, even on ordinary vessels.

In the field of topography few changes have been made in the

methods of work with the plane table, the most universally available instrument for mapping purposes, though some improvements have been made in the instrument and its appliances, chiefly in the direction of lessening weight and increasing rigidity. But in recent years there has been a notable advance in the application of photography to mapping purposes, the methods of phototopography being especially suited to many regions difficult of access, where it is important to obtain in a very brief interval in the field the greatest possible mass of observations capable of subsequent reduction, even at the expense of a greatly increased amount of office work. The improved topographic camera now used in the photographic work of the Coast and Geodetic Survey is an instrument of considerable precision, and by its use a few hours devoted to exposing plates at suitably selected stations may furnish the material for weeks of office work and for the development of a topographic map, the amount of detail given depending upon the frequency of the camera stations. In the work of the Coast and Geodetic Survey this method has been employed chiefly in Alaska, and especially in the vicinity of the Canadian boundary, a region of high, bare mountains, to which this method is very well adapted.

In the hydrographic work of the Survey, which furnishes the most vitally essential material for the charts, the principal recent changes in methods have been in the direction of greater closeness and precision, on account of the greatly increased demands of navigators, due to the enormous size and the great draft of many recently constructed ships. Lines of soundings are run at smaller intervals in order to give a closer development of the figure of the bottom, the lines so run are made practically continuous, when necessary, by the use of a quick-sounding device which gives casts at very frequent intervals and insures that no shoal spots occurring on the line between soundings can be passed without detection, and in cases where isolated rocks or other obstructions are suspected, the safety of a channel is further investigated by a sweep composed of iron tubes held rigidly in place beneath the surveying vessel and capable of adjustment to any desired depth within ordinary limits. With such a sweep a strip of bottom 60 feet wide may be examined for dangers at the depth desired with a single passage of the vessel, and by the multiplication of such lines of sweeping every portion of the suspected area may be covered.

A branch of political geography to which greater attention is constantly devoted as regions become settled and developed and as questions of jurisdiction thus become more urgent is the matter of boundary lines between coterminous nations, States, or minor political subdivisions. In frequent instances the Coast and Geodetic Survey has been called upon to locate and mark such lines of demarcation. Among these may be mentioned the boundaries between Pennsylvania and

West Virginia, between Delaware and Pennsylvania, between California and Nevada, between Maryland and Virginia, between Virginia and Tennessee, and between Pennsylvania and Maryland. An officer of the Survey was one of the commissioners to survey the international boundary between the United States and Mexico, and at the present time the Superintendent of the Survey is a commissioner for the United States in the matter of locating the Canadian boundary west of the Rocky Mountains and the boundary between Alaska and British Columbia. Work on the boundary west of the Rocky Mountains has been in progress since May, 1901. An officer of this service is detailed as chief astronomer of the expedition and an officer of the Geological Survey as chief topographer. These officers and their assistants share the work of the line tracing and triangulation.

Much time and labor have been devoted to the boundary between Alaska and Canada, in the preparation of maps and other information as a basis for negotiation, in the compilation of atlases for presentation to the international tribunal at London, and in expert assistance to the agent and counsel of the United States before that tribunal. Subsequent to the decision of the tribunal the Superintendent of this Survey was appointed commissioner for the marking of the boundary agreed upon and parties are now in the field for that purpose, working in conjunction with those sent out by the Canadian government.

Turning from methods of work to the consideration of ascertained geographic facts, some of the most interesting recent developments have been made on the coasts of Alaska, of Porto Rico, and of the Philippines. In Alaska, the survey of the delta of the Yukon has revealed a channel with a considerably greater depth than any previously known. The longitudes of several important points in Bering Sea have been carefully determined and the results obtained have in some cases shown considerable errors in previously accepted values. Prince William Sound and its approaches have also received much attention, and this large inlet seems likely to become in the near future one of the most important avenues of access to the interior of Alaska.

In this connection, it may not be inappropriate to refer to the suggestion recently advanced by Dr. R. A. Harris, of this service, based upon a careful study of the tidal phenomena of the Arctic Sea, that extensive bodies of still undiscovered land probably exist in the region between those coasts and the Pole.[a]

In addition to the chronometric longitudes in Bering Sea, mentioned above, prompt advantage was taken of the recent completion of the Pacific cable to determine by the telegraphic method the differences of longitude between San Francisco and Honolulu, Honolulu and Midway Island, Midway and Guam, and Guam and Manila. As the

[a] See paper published in the National Geographic Magazine for June, 1904, under the title "Some Indications of Land in the Vicinity of the North Pole."

longitude of Manila had been previously determined from the westward, these observations completed the circuit of the earth.

An interesting instance of the recent work of the Survey in its extension to our new possessions is afforded by the operations in and around the island of Porto Rico, which is of relatively small extent, and where, in consequence, the survey is already so far advanced toward completion that some general statements can be made in regard to the geographic results.

Porto Rico, the most easterly and the smallest of the Greater Antilles, lies between the parallels of 17° 56′ and 18° 31′ of north latitude and between the meridians of 65° 35′ and 67° 17′ of longitude west from Greenwich. The island is about 112 miles long and 40 miles wide in its greatest dimensions, and covers an area of about 3,350 square miles. In general outline it is remarkably regular, being roughly rectangular in shape, with its longer axis lying east and west. The eastern corners, especially the southeastern, are somewhat truncated, but its rectangular appearance on the map is sufficiently striking.

Porto Rico is situated upon the western half of a partly submerged plateau, which stretches westward from the Anegada channel, in longitude 64° 07′, to the Mona Passage, in longitude 67° 31′, a distance of about 222 miles between the curves of 100 fathoms depth. The eastern half of this plateau is, in general, submerged not more than 12 to 20 fathoms, and rises above the sea in the numerous peaks and rocks of the Virgin Islands, among which are usually counted Vieques, Culebra, and adjacent islets, which politically are part of Porto Rico.

West of Porto Rico and almost midway in the Mona Passage are the small islands of Mona and Monito. The latter is about 50 miles west of Point Guanajibo, south of Mayaguez. About 14 miles from Point Jiguero, in a direction a little north of west, is the small but very conspicuous island called Desecheo, which is the conical summit of a nearly submerged mountain rising several hundred feet above the sea and visible for more than 30 miles from either north or south. The water immediately surrounding it is from 1,000 to 3,000 feet deep. On the west coast of Porto Rico there are no other islands worthy of note, and on the north and south coasts the only islands of any importance are San Juan or Morro Island, on which the capital is situated, and the island of Caja de Muertos, about 8 miles southeast of Ponce Harbor.

East of Porto Rico, however, there are several small islands between the main island and the Virgin Passage, which forms the division between the possessions of the United States and of Denmark. Of these islands the largest are Vieques and Culebra, with respective areas of 51.5 and 11 square miles. The most eastern of the group is Culebrita, about 25 miles east of Porto Rico.

The seaward slopes of the submerged mountain mass of which Porto

Rico is the apex vary considerably in different directions but are greatest to the north. The Mona Passage, on the west, is relatively shallow; a ridge with only 800 or 900 feet of water over it running across the passage to the eastern point of Santo Domingo.

This seems to indicate a close structural relationship between the two islands. Farther east, in the Anegada Channel, the depth is much greater, more than 6,000 feet being found within 2 miles of the 600-foot curve. On the south side of Porto Rico depths of 9,000 feet or more are found 10 to 15 miles offshore and depths exceeding 7,500 feet at about 45 miles from the island.

North of the island the bottom drops to 6,000 feet in less than 15 miles, and to 27,000 feet in 70 miles.

The surface of the island is extremely irregular and in places mountainous, the main axis of uplift extending in a rude crescent from Mount Atalaya in the west to El Yunque in the northeast, the latter peak, the loftiest summit on the island, reaching an altitude of about 3,678 feet.

For the greater part of its length this mountain range nearly parallels the south coast of the island at a distance of from 5 to 15 miles. This is much less than the distance to the north coast, and the southern slope of the mountains is therefore much more abrupt than the northern. The water courses, which are numerous, show corresponding differences, those of the south being very short and little more than mountain torrents, while those of the north are much longer, in some instances drain considerable areas, and are sometimes navigable by flatboats in the lower parts of their courses.

Porto Rico was discovered in 1493 by Columbus, who landed near the present town of Aguadilla and took possession, for the Spanish crown, of the island, which he named San Juan Bautista. It was invaded in 1509 by the Spaniards, who, in the course of the following nine years subdued and practically exterminated the native inhabitants. The present population is composed partly of people of Spanish descent, partly of negroes, and in very considerable proportion of mixed blood, among whom it is said are to be found individuals showing well-marked characteristics of the aborigines. In 1899 the population of Porto Rico, exclusive of the Virgin Islands, was 946,601, or about 282 per square mile, although of the 69 municipalities only three, Ponce, San Juan, and Mayaguez, are of any special size or importance. The great density of population is, however, by no means apparent to the casual observer. In the rural districts the houses of the inhabitants are of so slight and inconspicuous construction, being usually made of poles covered with palm leaves, that they readily escape notice at a short distance, while the generally wooded hills give the island, as seen from the sea, the appearance of being almost uninhabited. The smokestacks of sugar plantations are occa-

sionally visible and sometimes the attached buildings may be seen or a glimpse obtained of some town or village. In general, however, these are screened from observation by groves of trees, usually cocoanut or royal palms, which are very abundant on the island.

The productions of Porto Rico are almost exclusively agricultural, the principal crops being sugar, coffee, and tobacco. The culture of fruit for the markets of the United States will no doubt soon become an important industry, as the island is well adapted to it and the voyage to the Atlantic ports of this country is very short.

It is also probable that the numerous attractions of the island, its beautiful scenery, its mild and equable climate, and its interesting historical and ethnological features, may cause it to become a popular winter resort. The improvement and extension of the means of transportation and the introduction of good hotels would go far toward that result.

The charts of Porto Rico obtainable in 1898 were inaccurate and misleading. This fact was so notorious that the British Admiralty, in its published sailing directions for this region, cautioned navigators not to approach the land closer than 4 or 5 miles. The Spanish Government also appreciated the inconvenience and danger of such a condition, and had taken measures to supply a remedy. Two commissions, one for the surveys of the land and the other for those of the water, were engaged upon a new survey when the events of 1898 put an end to their operations.

Shortly after the suspension of hostilities the Coast and Geodetic Survey, at the request of the Navy Department, made arrangements for beginning a survey of the Porto Rican coast, and in December, 1898, the steamer *Blake* was dispatched for that duty. On account of the very scanty information in regard to the south coast of the island and of various reports which had reached Washington of good but unknown harbors, it was decided to begin the survey on that coast.

Work began at Ponce about the middle of January, 1899, with the measurement of a base line, astronomical and trigonometric observations, and a topographic and hydrographic survey. By special authority of the superintendent a chart of Ponce Harbor and approaches was at once prepared and was issued in blueprint to Government officials and to shipmasters. From Ponce the survey was extended to the eastward. Between Ponce and Arroyo was developed, besides other practicable roadsteads, the landlocked harbor called Jobos, previously known only by rather vague reports. During this first season a careful survey on a large scale of the very important harbor of San Juan, on the north coast, was made especially for the use of the admiral commanding the North Atlantic Squadron. Subsequent work has developed good harbors at Guayanilla, on the south coast, and at Boqueron, on the west coast.

In the following year, 1900, the Navy Department requested an immediate survey of Culebra Island, on the eastern side of which is one of the best harbors of this region. The steamer *Blake* and the schooner *Eagre* were engaged on the work in this vicinity and in the whole region between Porto Rico and St. Thomas, which were connected by triangulation. Latitude and azimuth were also determined at Culebra. In this season the schooner *Matchless* was at San Juan, engaged in the extension and completion of the harbor survey begun the year before. Parties working on land made trigonometric connection between the north and south coasts and extended the coast triangulation and topography. The latter work was completed during 1901 and 1902, while the hydrographic surveys were continued during those seasons and the two which have followed, at least two vessels having been usually employed on this work, besides parties working from the shore with launches.

Owing to the scarcity of harbors on the north coast and to the close approach of deep water, its survey has been less urgently needed, but these conditions will operate to increase the difficulty and danger of the survey when it is finally taken up.

The geodetic connection between San Juan and Ponce developed a discrepancy in the latitudes of the two places obtained by astronomical observations amounting to more than 56″ of arc. This remarkably large station error is no doubt due to the abnormal distribution of the earth masses already mentioned. Four latitude stations are included in the net of triangulation which covers Porto Rico and extends to St. Thomas, viz: San Juan, Battle Cay (Culebra), St. Thomas, and two stations near Ponce—Muertos Light-House and Aduana de Ponce. The last two were sextant determinations by the Spanish Conde de Canete, and in the discussion their mean was used as one result. All of the others were zenith telescope determinations—those at San Juan and at St. Thomas by the United States Navy and that at Battle Cay by the Coast and Geodetic Survey.

The trigonometric connection was made by the Coast and Geodetic Survey, and the adjustment showed that the observed latitudes, as compared with the geodetic, were 33″.12 too great at San Juan, 23″.18 too small at Ponce, 7″.78 too small at St. Thomas, and 1″.68 too small at Battle Cay. Except at this last station, where the discrepancy is small, the direction of the discrepancy agrees with what might be expected from the situation of the stations with reference to the great mountain mass, mainly submerged, upon the sides of which they stand. The amount of the discrepancy is, however, surprising, and this region evidently affords an interesting field for future investigation in this regard.

THE WORK OF THE COAST AND GEODETIC SURVEY IN THE PHILIPPINE ISLANDS

The facility with which surveys may be made in any region depends largely on the geography, climate, vegetation, and culture. These remarks will, therefore, be prefaced by a brief general description of the Philippine Islands, pointing out especially such features as affect the important engineering problem of surveying the coasts of the archipelago.

GENERAL DESCRIPTION

The Philippine Islands lie entirely in the north tropic zone, between the parallels of 4° 30′ and 21° 25′, approximately. They include a compact group extending from Luzon to Mindanao, from which two narrow chains of islands stretch southwestward nearly to Borneo and another chain stretches northward toward Formosa. Throughout the main group one may pass from island to island with no intervening distance greater than 30 miles. The total area within the boundaries of the archipelago is estimated to be 832,968 square miles, and the land area 115,026 square miles. More than two-thirds of the land area is included in the two islands Luzon and Mindanao, but there are 31 islands which have an extent greater than 100 square miles each. There are, approximately, 3,141 islands and islets in the archipelago. The general coast line measures about 11,444 statute miles, or a mile of coast line to every 10 miles of area. The islands are nearly all of elongated or irregular figure, so that no point in any island is more than 60 miles from some part of the coast.

The greater part of the land is mountainous, the only extensive level areas being the valleys of some of the larger rivers, which are bordered by ranges on either side. Excepting some of the higher mountains and volcanic craters and the hills in thickly settled regions, the summits are in general heavily timbered.

An excellent general representation of the Philippine Islands is given by the large outdoor relief map constructed under the direction of Rev. José Algué, S. J., in the grounds of the Philippine reservation at the Louisiana Purchase Exposition.

The coasts of the islands are of almost every variety, ranging from sandy beach to precipitous cliff. An important feature to the hydrographer and to the navigator is the extensive fringe of coral reef bordering the shores of considerable portions of the islands and forming large areas of shoals and dangers in some of the passages and inclosed seas. These reefs and the shores in many places are abrupt and the adjacent waters are often too deep for anchorage. This feature greatly

limits the suitability of some of the roadsteads and bays for the protection of vessels. Because of the typhoons to which the region is subject, well-sheltered anchorages are of great importance, and a number of such exist, but some of these are suitable only for coasting vessels. Some of the inclosed seas are shoal, as that north of Negros, while in the Jolo Sea, southwest of the same island, there are soundings of over 2,000 fathoms.

The temperature is warm throughout the year, frost being unknown at ordinary elevations. At Manila the range is but 40° F., ranging from 60° F. to 100° F., but the latter temperature has been reached only twice in 16 years, the maximum seldom exceeding 90° F.

Northeasterly and easterly winds, generally termed the northeast monsoon, prevail from November to April, and southwesterly winds from May to October. The islands lie in the track of the typhoons, which appear to originate to the southwestward and cross into the China Sea or curve to the northward. These storms are most prevalent from June to November. While the danger area is usually small, the passage of typhoons has a marked effect on the weather over a large area, bringing continuous rain and changes in the wind.

The precipitation is directly dependent on the winds and the location. There is a marked rainy season at Manila and generally on the west coasts of the islands, beginning in June and continuing through the southwest monsoon and the typhoon season. During the northeast monsoon season there is as distinct a dry season on the west coasts, with a minimum rainfall in February. On the east coasts of the islands the conditions are to some extent reversed, but the rainy and dry seasons are much less marked. The rains accompanying typhoons affect both coasts, and as the typhoon season to some extent coincides with the southwest monsoon season, these storms tend to distribute the rainfall throughout the year on the east coasts while they accentuate the rainy season on the west coasts.

These weather conditions are of great importance in planning survey operations, and with proper selection of locality it is possible to carry on field operations in either of the seasons.

The population of the Philippine Islands, according to the census of 1903, was 7,635,426. Some of the islands are thickly settled, while others have but a sparse population. For instance, of the larger islands, Mindoro has but 28,361 people and Paragua 10,918. There are numerous settlements along the coasts of nearly all the islands, and the population naturally depends largely on water transportation, furnished by small coasting steamers as well as by native boats. The relative extent and importance of the water highways of the islands increase the necessity for hydrographic and coast surveys

ORGANIZATION OF WORK IN THE PHILIPPINES

After a preliminary investigation, made in 1900, of conditions and requirements, active field work was commenced by the Coast and Geodetic Survey in the Philippine Islands in January, 1901, and it has been prosecuted continuously since that time. The work is conducted under a joint arrangement between the National and insular governments, and under the general supervision of the superintendent at Washington. A suboffice of the Survey is established at Manila, through which the details of the work in the islands are arranged. In this office the records are received, computations are made, charts and sailing directions are prepared, and information is supplied to navigators, engineers, and others. A considerable force of Filipinos is employed in this office, but each part of the work is under the supervision of experts sent from Washington.

In the field work two steamers regularly fitted out for coast survey work are employed, and a third steamer is now under construction. These vessels generally carry out the complete surveys, including triangulation, hydrography, and topography. In addition, launches have been chartered in a number of cases. Considerable work has been done by shore parties, which have surveyed small harbors, carried trigonometric and topographic surveys along the coast, and determined astronomic positions and the magnetic variation at various points.

STATE OF INFORMATION IN 1898

The Philippine Islands were discovered in 1521 by Magellan, but few maps of the archipelago appear to have been made until the following century. The best known early map is that of the Jesuit father Murillo Velarde in 1734. Among the important early explorations was that made by the expedition of Malaspina in 1792 and 1793. The Spanish Government in 1834 organized a commission for charting the islands. Steam vessels were first introduced in 1847. From this time surveys and explorations were prosecuted more continuously, and at the time of the transfer of the islands a considerable mass of material had been accumulated, as is shown by the fact that 125 different charts of the islands were published in Madrid. The British had contributed much to the cartography of the islands, particularly in the reconnaissance of the coasts of the island of Paragua made in 1850–1854, and in surveys made in Balabac Strait and the Jolo Archipelago. The United States exploring expedition under Wilkes visited the islands in 1842 and published a number of plans. American naval officers determined telegraphically the longitude of Manila from Hongkong in 1881. The charts show that one harbor each was surveyed by French and Italian vessels.

No systematic survey of the interior of the islands had been undertaken, but detached explorations were made by various branches of the local government, particularly by military expeditions and in connection with the geological, mining, and forestry investigations. The members of the order of Jesuits also made extensive explorations, particularly in the less-known parts of the islands.

In view of the great extent of the coast line and the difficulties encountered in this region it is not surprising that, notwithstanding the work done, considerable portions of the coasts remained practically unsurveyed in 1898, and this is particularly true of the east coasts of Luzon, Samar, and Mindanao, and the south coast of the latter island. Of many other parts of the islands also the information was necessarily incomplete. The more completely charted regions apparently were the area between Masbate, Samar, and Leyte, and portions of the Jolo Archipelago, and some of the more recently surveyed harbors, as Port Misamis.

PROGRESS OF SURVEYS SINCE THE TRANSFER OF THE ISLANDS

The field work of the Coast and Geodetic Survey in the Philippine Islands has been planned to meet the more important needs of the charts for navigation and to furnish a basis for the systematic extension of surveys, but all operations have necessarily been controlled by the facilities available and conditions existing.

A considerable number of positions have been determined astronomically, to serve as base stations from which to extend surveys. These points are well distributed wherever the telegraph was available. The latitudes have been determined by the zenith telescope and the longitudes by the telegraphic method, the wide extension by the Signal Corps of the telegraph lines and cables having afforded facilities for this work. A determination of the longitude of Manila has recently been completed through the new Pacific cable from San Francisco. As Manila had previously been connected with Greenwich through Hongkong, this completes a longitude circuit around the world.

The more important surveys made include the following: San Bernardino Strait, Albay Gulf, and Lagonoy Gulf, including the important hemp ports on the southeast coast of Luzon; Tacloban Harbor, San Pedro Bay, and the south coast of Samar Island; Lingayen Gulf; parts of Guimaras and Iloilo Straits, between Panay and Negros; Ormoc Bay; the passage between Leyte and Bohol; part of the north coast of Panay; Cebu Harbor, Halsey Harbor, Manila and Cavite anchorages, and a number of other harbors. Each of the foregoing includes hydrographic and topographic surveys, based on triangulation, and usually referred to one or more of the base astronomic stations. In addition, triangulation and topography have been carried

along the west and north coasts of Luzon from Subig Bay to Aparri and a triangulation has been made across Manila Bay. From Manila Bay it is proposed to carry the triangulation northward through the valley of Luzon and southward across the channels as far as Mindanao, to form a main framework from which in the future both the coast and other surveys may be extended. The hydrography and the topography of the coasts will be extended where most needed, as facilities permit.

Tidal observations have been made at a considerable number of points for use in reducing the soundings and for the prediction of tides to be given in the Tide Tables. The magnetic declination has also been determined in many places.

Information as to the geography of the Philippines has also been increased from other sources during the past few years. Numerous reconnaissances and explorations have been made by army officers, principally in connection with the military operations, and these have been embodied in military maps. Officers of the Navy have made a number of harbor surveys and reconnaissances in connection with the selection of naval stations and other duties, and some positions have been determined astronomically. Surveys for harbor improvements have been made by the army engineers and by the bureau of engineering. Explorations have been made by the Philippine forestry and mining bureaus.

A REMARKABLE COLONY OF NORTHERN PLANTS ALONG THE APALACHICOLA RIVER, FLORIDA, AND ITS SIGNIFICANCE

By H. C. COWLES, University of Chicago

[Abstract.]

The topography of Florida in the neighborhood of the Apalachicola River is in striking contrast to the level areas in other parts of Florida and the adjoining States. There are high river bluffs and deep ravines with steep slopes. In these ravines, and especially on the northward-facing slopes, is to be found a mesophytic association of plants that is abundant far to the north, but which reaches its southern limit here. Among the plants of this association are beech, maple (*Acer floridanum*), Mitchella, Hepatica, Sanguinaria, Epigæa, Anemonella, and many other species that dominate in mesophytic northern woods. In this association one finds two of our most notable endemic plants—Torreya and Croomia. It seems likely, then, that we should regard *Torreya taxifolia* as a northern mesophytic left stranded to-day only in Florida. It presumably is one of the plants that failed to follow up the last retreat of the Pleistocene ice, and is preserved here perhaps because of exceptionally favorable topographic conditions. These facts may help to determine the nature of the pre-Glacial climates, since Torreya was then a widespread form.

DISCUSSION

Dr. J. W. SPENCER called attention to the canyons incising the submarine continental border as evidence of a great elevation during part of the Pleistocene period, which would favor the migration of northern plants to Florida, and, other things being equal, the remaining of the plants is an additional suggestion of the correctness of the hypothesis of the late elevations shown by the canyons.

IMPORTANCE OF THE PHYSIOGRAPHIC STANDPOINT IN PLANT GEOGRAPHY

By H. C. COWLES, University of Chicago

[Abstract.]

The larger the number of valid standpoints there are in a science the greater is the likelihood of a correct orientation of that science. The advocates of a physiographic standpoint in plant geography do not assert that it is the only correct standpoint, but contend that from it a better insight may be had into many dark problems. In particular does it assist in the study of the life history of plant associations, since it enables one to read with comparative ease the immediate past and future of any given landscape. It gives perhaps a better view of dynamic aspects than any other standpoint, a feature of importance in a dynamic world. Since it is relatively easy to classify any region physiographically, it follows that one may classify the plant associations on a physiographic basis with comparative ease. This is decidedly important, inasmuch as most classifications of plant associations have been difficult to apply.

METHODS OF DETERMINING THE AGE OF THE DIFFERENT FLORISTIC ELEMENTS OF EASTERN NORTH AMERICA

By J. W. HARSHBERGER, Ph. D., Philadelphia, Pa.

The methods which must be adopted in scrutinizing the flora of a country are several:

1. The botanist must determine the past and present physiography of the region concerned.

2. He must determine, if possible, the geologic time at which the recorded physiographic changes took place.

3. He must recognize the indigenous species by eliminating the derived.

4. A study of the distribution of species will enable him to determine to some extent the age of the different floristic elements, and the application of the following criteria will also aid him in the solution of questions such as are considered here:

(*a*) Location of greatest differentiation of type.

(*b*) Location of dominance or great abundance of individuals.

(*c*) Location of synthetic and closely related forms.

(*d*) Location of maximum size of individuals.

(*e*) Location of greatest productiveness and its relative stability.

(*f*) Continuity and convergence of lines of dispersal.

(*g*) Location of least dependence upon a restricted habitat.

(*h*) Continuity and directness of individual variations, or modifications radiating from the center of origin along the highways of dispersal.

(*i*) Direction indicated by biogeographic affinities.[a]

5. Old regions, botanically speaking, may be determined where the number of specific forms of single genera is small, and new regions may be determined when the number of species of single genera is ordinarily very large.

6. Drude's classification of endemic plants as corresponding and as relict is of great assistance to the botanist in determining the age of floristic elements. Plants are corresponding when the original con-

[a] Adams, Chas. C., Biological Bulletin, III, p. 122.

tinuous area of a variable species has been interrupted in such a way as to form several smaller areas occupied by subspecies or new species, while relicts are those species originally of extensive distribution able to maintain themselves in a limited area only on account of changed conditions of life.

So that the historic element must be considered in a phytogeographic study of any country. Many questions concerning the present distribution of plants depend upon the character and extent of the past distribution of the species of any region or formation. The degree of invasion of new species into a region is determined by the presence or absence of vegetation. If vegetation is present, then the botanist is compelled to account for its presence by a consideration of the physiographic history of that part of the earth's surface, the association of species, and the probable origin of these species, whether indigenous or derived. The determination of the indigenous and derived species of a formation or larger division is of the utmost importance, as it enables us to retrace the steps by which the formation has reached its present condition and association of species and to reconstruct formations that have long since disappeared.

Having enunciated these general principles, I will endeavor to apply them in the determination of the age of the different floristic elements of eastern North America.

All of eastern America, north of the great terminal moraine which marks the southern boundary of the great ice sheet, with the exception of the nunataks, has been tenanted by plants which have migrated into the territory abandoned by the great continental glacier. Geologists believe, from evidence afforded by the time that it has taken for the river to cut the gorge at Niagara, that ten or fifteen thousand years have elapsed since the close of the Glacial period. If their deductions are sound, then the flora of the northern part of eastern America can not be older than fifteen thousand years at the outside. Some of its elements may be much older, and we have reason to believe that many boreal plants existed as such on the nunataks which were unglaciated areas above the great ice sheet. The first wave consisted of the distinctly Glacial flora which skirted the border of the ice sheet. The second wave, younger as a floristic element of the North, consisted of boreal plants, many of which, as bog plants, tenanted the bogs and margins of the glacial lakes that were formerly much more abundant in the north than at present. These bog and tundra types pushed early into the barren ground left by the retreating ice. The tundra was closely followed by the coniferous forests on the western and eastern sides of the glaciated areas, and these trees constitute a third floristic element much younger in point of the time in which they have occupied the north. These trees and those forming a still younger element surrounded the bog plants societies, which

were thus trapped by the surrounding tree vegetation, and, as the bog was gradually transformed by biologic influences into firmer ground, gradually encroached on the bog plant associations. Present bog habits are continuations of similar habitats which existed in early post-Glacial times, when tundra conditions and tundra vegetation were dominant. The fourth element just mentioned consisted of deciduous shrubs and trees—oaks, hickories, and the like—which at present are south of the great coniferous belt of forest. In the east, among the highlands, exceptional circumstances were afforded for the preservation of the northern forms.

The flora of Mount Washington is perhaps an exception to this. During the Glacial period it was a nunatak, and during this time it was tenanted by such plants as *Silene acaulis*, *Arenaria grœnlandica* Spreng., *Geum radiatum* Michx., *Solidago virga-aurea* L. var. *alpina* Bigel., *Prenanthes bootii* Gray, *Cassiope hypnoides* Don., *Bryanthus taxifolius* Gray, *Diapensia lapponica* L., *Oxyria digyna* Hill., *Salix phylicifolia* L., *Salix uva-ursi* Pursh., *Salix herbacea* L., *Phleum alpinum* L., *Lycopodium selago* L., etc., which have remained as permanent tenants of this mountain.

If we take Mount Washington as a mountain, the summit flora is older than that of the lower alpine slopes of the mountain above timber line, and the flora of these slopes is in turn older than that of such gorges as Tuckermans Ravine, Huntingdon Ravine, and Great Gulf, which probably supported local glaciers for many centuries after the great ice sheet had retreated from the Presidential Range.

Mount Katahdin, 161 miles northeast of Mount Washington, has a less number of alpine plants than the other mountain, and some geologists believe it to have been buried entirely beneath the Glacial ice sheet. If that is so, then the alpine flora of Mount Katahdin is, as a floristic element, much younger in point of time than that of Mount Washington. The same differential arrangement of the plants on Mount Katahdin is found as on Mount Washington. The place where the boreal flora, upon the retreat of the continental ice sheet, encroached upon Mount Katahdin is determined largely by the physiography of the mountain.

The glaciers occupying the various basins of the mountain retarded the revegetation of the mountain, but with a favorable opportunity the encroachment perhaps began from the southwest and west. This idea seems to be confirmed by the present distribution of the spruce and fir, which ascend higher on this side, and their apparently greater age. As to the east side of the mountain and in particular the basins, it seems probable[a] that the great basin was first tenanted by plants and that the north basin opposed this migration a much longer time

[a] Harvey, L. H., A study of the physiographic ecology of Mount Katahdin, Maine, University of Maine Studies No. 5, Dec., 1903.

for the reason that this basin, which presents a scene of desolation, was the seat of a local valley glacier which was perhaps the last to disappear. As a consequence, the basin presents an appearance even more xerophytic and alpine than some of the upper parts of the mountain itself. The pucker bush (Krummholz) reaches here an unusual development, with the trees lying in most places prostrate and gnarled and twisted to a high degree.

Another interesting problem which presents itself is that of the presence of typical seashore plants on the coasts of the Great Lakes. Such plants as *Ammophila arundinacea* Host., *Sabbatia angularis* Pursh., *Lathyrus maritimus* Bigel., *Hudsonia tomentosa* Nutt., *Cakile americana* Nutt., *Hibiscus moscheutos* L., *Gerardia purpurea* L., *Euphorbia polygonifolia* L., *Myrica cerifera* L., are found not only on the shores of the Great Lakes, but some of them near the Lake of the Woods. The most satisfactory explanation seems to be that in post-Glacial times the valleys of the St. Lawrence, Hudson, Lake Champlain, and probably also Lakes Ontario and Superior, were then occupied by the sea, because of the northeast depression of the land. During this period of submergence the typical seashore plants gained access to the interior of the continent.

An interesting confirmation of this position is found in a study of the succession of the floras on the Pocono Mountain plateau following the destruction of the original forest by lumber operators. The original vegetation of this plateau consisted, as far as I have been able to determine, of four elements, viz, a forest of pitch pine (*Pinus rigida* Mill.), which covered the looser morainic material of the great terminal moraine in the eastern and southern parts of the plateau, the broad-leaved deciduous forest with its oaks and associated species on the eastern slopes and edge of the table-land, the chestnut and black locust forest which occupied Laurel Ridge along the western rim of the plateau, and a forest of white pine with a thicket of *Rhododendron maximum* L. beneath, mixed in many places with the black spruce (*Picea nigra* Link), the red maple, and other plants characteristic of the Catskill Mountains and regions farther north. The open sphagnum bogs culminated in the presence of the larch (*Larix americana* Michx.), with which were associated *Kalmia glauca* Ait., *Ledum latifolium* Ait., *Rhododendron rhodora* Don., and other northern plants. With the destruction of the white-pine, hemlock, and pitch-pine forests the vegetation of this table-land has undergone an entire change. The succession of the species has not been worked out in detail, but what has been observed is instructive. The botanist is impressed by the general appearance of the landscape. The flora over the eastern half of the plateau in aspect resembles that of the pine-barren regions of southern New Jersey from which the original pitch pine and Jersey pine have been cut. A study of the species shows that this appear-

ance is due to the close similarity of the flora in the plant species which constitute the two regions. We have an instructive example of mass invasion of such plants as *Quercus ilicifolia* Wang., *Pinus rigida* Mill., *Gaylussacia resinosa* Torr. and Gray, *Vaccinium vacillans* Solander, *Epigæa repens* L., *Gaultheria procumbens* L., *Rhododendron viscosum* Torr., *Kalmia angustifolia* L., *Lilium philadelphicum* L., *Amianthium muscætoxicum* Gray, *Lycopodium inundatum* L., etc., from the morainic hills westward into the region once occupied by the white pines. We naturally inquire from what locality the pitch-pine formation has proceeded, and it seems to me we are forced to conclude that this association of species has been derived not from the barrens of New Jersey but from the Kittatinny and other near-by mountains northwest of the Delaware Watergap, which support such a flora. This relict flora on the Kittatinny and other highlands has been under unusual stress of circumstances, and when more favorable, but on the whole similar, edaphic conditions were supplied, a mass invasion from these mountain highlands took place. Similarly, when the glaciers retreated a mass invasion of pitch pines and associated species moved from the unglaciated Kittatiny Mountains onto the sandy-gravelly soil of the great moraine, and when the lumbermen disturbed the forest these plants, adapted to growing in sandy soils and exposed to xerophytic conditions, supplied the constituent elements of the present flora in the greater part of the eastern half of the plateau.

A consideration of the strand flora of New Jersey, upon which I have spent considerable study, reveals the fact that the time element is important in an explanation of the distribution of the seashore plants. If we contrast the character of the association on the northern and southern shore of New Jersey, we find that the formations on Barnegat Beach, for example, are usually open, while those on Wildwood Beach are closed and have culminated in the forest type of vegetation. This argues for a greater age of the strand flora of Wildwood, as compared with that, for example, at Seaside Park in the north. This conclusion is substantiated by the fact that the bays behind the sandy sea islands are converted into salt marshes in the south, while in the north they are wide and still open bays of brackish or salt water. Physiographically and botanically the coast line from Bay Head south to Ocean City is younger than the coast south of the latter place extending to Cape May.

The floras of the region south of New Jersey, including southeastern Pennsylvania, may be divided historically, according to their ages, into several well-marked divisions, which are named below in the order of their development, the older being given first.

(1) The flora of the southern Appalachians and its northeastern extension into southern and southeastern Pennsylvania. The facts

presented by me in two former papers[a] all argue for the great antiquity of the flora of North Carolina and southeastern Pennsylvania, because this flora, in all probability, represents the more or less modified descendants of that characteristic flora which, in later Eocene or Miocene time, extended to high northern latitudes.

(2) The flora of the coast plain occupied by the long-leaf pine and its associated species, which probably represent the ultimate stages of successions initiated at the time of the final elevation of the sea bottom along the coast line. These plants probably entered the elevated coastal region by a mass invasion from a circumscribed area contiguous to the Atlantic shore line, for it has been established that contiguous vegetation furnishes 75 to 90 per cent of the constituent species of an initial formation. The reason for this is to be found not only in the fact that adjacent species have a much shorter distance to go, and hence will be carried in greater quantity, but also in the fact that species of the formations beyond must pass through or over the adjacent ones. In the latter case, Clements states that "the number of disseminules is relatively small on account of the distance, while invasion through the intermediate vegetation, if not entirely impossible, is extremely slow, so that plants coming in by this route reach the denuded area only to find it already occupied.[b]

(3) Plants of probable Neotropic origin which have, according to Kearney, in all likelihood made their first appearance in the Appalachian region in geologically very modern times, probably after the close of the so-called Glacial epoch.

(4) A relict flora of a former widespread plateau region in which we find a close similarity between the flora of some of the higher mountain summits and the flora of the coastal plain. We have previously mentioned in the physiographic changes which have taken place in this mountain region an explanation of such peculiarities of distribution. The presence of *Hudsonia montana* Nutt. on the summit of the Table Rock is probably thus explained, for Table Rock represents an undenuded remnant of a former peneplain. It is likely, therefore, that *Hudsonia montana* Nutt. was once more extended in its distribution, but has been isolated by the erosion of the mountains and plains on which it formerly grew in abundance. The presence of *Leiophyllum buxifolium* Ell., *Xerophyllum asphodeliodes* Nutt., and *Amianthium muscætoxicum* Gray on the mountain summits and on the coastal plain is also similarly explained.

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[a] Harshberger, J. W., An ecologic study of the flora of mountainous North Carolina, Botanical Gazette, Vol. XXXVI, pp. 241-258, 368-383, 1903; and A phytogeographic sketch of extreme southeastern Pennsylvania, Bulletin Torrey Botanical Club, Vol. XXXI, pp. 125-159, March, 1904.

[b] Clements, Frederick E., Studies of the vegetation of the State: III. The development and structure of vegetation. Botanical Survey of Nebraska, 1904.

Lastly are the ruderal plants and weeds that, introduced by the hand of man, have become established in America. The history of the introduction and spread of many of these plants is well known, whereas many have appeared and become established whose history is involved in considerable doubt. The time which has elapsed since the advent of these outsiders does not exceed two hundred or three hundred years, and yet in that time many American varieties of common European plants have, by mutation or otherwise, arisen to demarcate the American from the European forms.

DIE METHODE DER PFLANZENGEOGRAPHISCHEN KARTOGRAPHIE, ERLÄUTERT AN DER FLORA VON SACHSEN

Von Professor Dr. OSCAR DRUDE, Dresden

Der hier der biogeographischen Section vorzutragende Gegenstand schliesst sich an einen Vortrag an, den ich im September 1899 auf dem Geographencongress zu Berlin hielt. Was ich aber damals mehr theoretisch besprach, ist heute in einem mir ganz besonders vertrauten, kleinen Florenbilde aus Deutschland fertig entworfen: es liegt hier vor (*a*) eine floristische Übersichtskarte von Sachsen in 1 : 250,000, entworfen auf der neuen Grundlage der geologischen Übersichtskarte von Sachsen, und (*b*) vier Blätter der Generalstabs-Karte von Sachsen in 1 : 100,000, nämlich Sectionen Dresden, Bischofswerda, Dippoldiswalda und Königstein, welche alle vier zusammen die Karte der weiteren Umgebung von Dresden zwischen dem Erzgebirge bei Altenberg in mehr als 800 Meter Höhe, dem Elbtale selbst in etwa 100 Meter Höhe, und den niedrigen, das Elbtal im Norden begleitenden Hügelketten und Hochebenen der Oberlausitz in 200–400 Meter Höhe darstellen. Die floristischen Aufnahmen, welche dieser Handzeichnung mit Aquarellfarben zu Grunde liegen, sind alle im Laufe der vorhergehenden Jahre von mir selbst ausgeführt.

Hier soll aber natürlich, auf einem Geographentage in Nord-Amerika, nicht von der Flora Sachsens und iher pflanzengeographischen Formationsgestaltung die Rede sein, sondern von der bei solcher pflanzengeographischen Kartirung anzuwendenden Methode. Auch soll hier nur ein kurzer Auszug wiedergegeben werden, weil die Einzelheiten ohne Einblick in die beiden Karten selbst nicht gut zu verstehen sein würden. Eine ausführlichere Darstellung bleibt einer späteren Veröffentlichung vorbehalten.

Es sind solche specielle Karten, wie meine Blätter in 1:100,000 in den Farben pflanzengeographischer Formationen, bisher nur an wenigen Stellen in Europa in Angriff genommen worden, nämlich von Ch. Flahault in Montpellier, von den Brüdern Smith im südlichen Schottland, von C. Schröter und seinen Schülern in den Schweizer Alpen,

und endlich von mir selbst. Unmittelbar vor meiner Abfahrt von Europa lernte ich noch den Anfang einer pflanzengeographischen Kartographie von Österreich kennen.

Alle diese Karten weichen in ihrer Methodik mehr oder weniger von einander ab. Charles Flahault, welcher zu unser Aller Bedauern durch Krankheit verhindert wurde, hierher zu kommen und an dieser Sitzung mit Teil zu nehmen, hat seine Methode am ausführlichsten besprochen. Sie stellt auf Karten des Nordabhanges der Pyrenäen in Südfrankreich in 1 : 200,000 in der Hauptsache die Areale vorherrschender Bäume oberhalb der Littoralregion dar und deckt die einzelnen Stücke des Landes mit einer gleichmässigen Farbe. Smith hat bereits in der Einleitung zu seinen schottischen Karten hervorgehoben, dass im nördlichen Europa eine Abgrenzung nach einzelnen Baumarten nicht ausführbar erschiene, und in Berlin setzte ich dasselbe in Bezug auf specielle Landeskarten der deutschen Flora auseinander. Es handelt sich überhaupt nicht um die Verbreitung einzelner Pflanzenarten, sondern um die gegenseitige Ablösung der Formationen in Abhängigkeit von der Landestopographie, und Flahault erstrebt dies in seiner Weise gerade so gut als ich.

Es soll aber zugleich eine solche Karte die Resultate der pflanzengeographischen Forschung in Verbindung mit dem Kultur-Zustande des Landes bringen. In dieser Verbindung muss für die durch Kultur stark veränderten Länder Europas ein besonderes Schwergewicht gesucht werden; denn die Pflanzenkultur ist von denselben natürlichen Einflüssen abhängig, wie das Vorherrschen bestimmter Formationen im Naturzustande. Ich habe dies am besten dadurch auszudrücken geglaubt, dass ich das angebaute Land in denselben Farben gehalten habe, wie diejenigen Formationen, aus denen es ursprünglich hervorging (in der Hauptsache also Wald und Grasland); aber das Kulturland ist in parallelen Schraffir-Linien gehalten, die natürlichen Formationen in vollfarbig angelegten Flächen.

Dadurch wird bewirkt dass die Reste natürlicher Formationen in dem von der Kultur am stärksten veränderten Lande, wie in Sachsen südlich der Elbe um Meissen, nicht so grell aus den Kulturfeldern heraustreten, wie es bei der Karte von Smith aus der Umgebung Edinburghs der Fall ist. Auch ist es dem Pflanzengeographen gleichgültig, ob hier oder dort ein Eichenhain übrig geblieben ist der schon im nächsten Jahrzehnt abgeschlagen sein kann, während vielleicht ein neuer vom gleichen Grundcharakter angepflanzt wird. Um so mehr heben sich die Hauptabteilungen des Landes durch Vorwiegen gleicher Farben heraus.

Die Zahl derselben beträgt auf diesem Stück Sachsens, welches alle Formationen des Landes mit Ausnahme der obersten Wälder und Matten in 900–1,250 Meter Höhe enthält; nur zwölf, welche allerdings

durch Combination unter einander zur Bezeichnung einer doppelten Anzahl von Formationen verwendet worden sind.

Diese Hauptfarben und ihre Combinationen sind folgende:

1. Violett: Laubwälder (*Fagus*, *Quercus*, *Carpinus*, *Fraxinus*, etc.).

2. Braunviolett: montane Nadelwälder (*Abies*, *Picea*).

3. Gelbbraun: trockener Kiefern-und Birkenwald (*Pinus silvestris*, *Betula alba*).

3×2 in schräger Streifung: montaner Kiefernwald mit Fichte, meist nur von 400–600 Meter.

1×3 in schräger Streifung: untere montane Mengwälder von *Fagus*, *Acer pseudoplatanus*, *Ulmus*, etc., mit *Abies* und *Picea*, meist in den Flusstälern.

4. Moosgrün: Moorwiesen auf Torfboden.

3×4 in liegender Streifung: Kiefernwald auf feuchtem Torfboden mit Fichte und Riedgräsern, nur in der Lausitzer Niederung und ohne montane Stauden.

5. Schwarzgrün: Bruchwälder aus Laubgehölzen (*Alnus*, *Quercus*, *Tilia*, *Ulmus*).

5. Schwarzgrün in schräger Streifung: Auenwälder derselben Laubbäume, ohne Fichte und Buche.

6. Purpurrot: montane Felsen (hauptsächlich Basaltkegel).

6×1 in Bergzeichnung: Berglaubwälder auf Basalthöhen.

7. Gelb: Sandfluren und sandige Abhänge der Quadersandsteine bis 400 Meter.

7×3 im Anschluss: Kiefernheiden auf Sandboden; Calluna.

8. Orangerot: trockene Hügel und Felsabhänge in der warmen Region 100–300 Meter.

8×3 im Anschluss: lichte Haine von Kiefer und Birke mit der pontischen Association (*Cytisus nigricans*, etc.).

9. Dunkelgrün: Auwiesen und Talwiesen bis ca. 400 Meter.

10. Hellgrün: Bergwiesen, nicht unter 400 Meter (*Meum athamanticum*, *Cirsium heterophyllum*, etc.).

11. Dunkelbraun: Moosmoore, Sphagneten mit *Eriophorum vaginatum*, *Pinus montana*, etc. (Nur im Gebirge Sachsens.)

12. Blau: Wasser; Teiche, Seen, Flüsse und Bäche.

In verschiedenen Combinationen 12×9, 12×10, 12×4, 12×5 und 12×2 werden die sehr verschiedenen Pflanzenbestände der Bäche und Flüsse vom Berglande bis herab zu der Elbe und den Lausitzer Teichen dargestellt.

Mit der Anwendung dieser Farben ist es möglich, der Anordnung der Formationen auf Grundlage der Topographie des Landes gerecht zu werden. Der Kenner des Landes findet die geographische Gliederung desselben sofort heraus; die tief eingerissenen Schluchten des Elbsandstein-Gebirges (sächsische Schweiz), welche montane Stauden an den Bächen in 250 Meter Höhe führen, während oben darüber, auf den Sandsteinhöhen des Königsteins und Liliensteins, trockener Kiefernwald mit Heide die sonnigen, trocknen Flächen deckt; dann die sanft gerundeten Abhänge des Erzgebirges, auf denen bis gegen 500 Meter Höhe herunter die Bergwiesen mit *Meum* sogar einen Bestandteil der Kulturen zwischen Roggenfeldern ausmachen; die reiche Weinbergs-Gegend des Elbtals (eng angeschlossen an Farbe 8!), und die Kiefernheiden mit Moorwiesen und Bruchwäldern in der Lausitzer Niederung an der Nordgrenze von Sachsen.

In dieser Weise, denke ich, leistet die botanische Formationslehre als Unterlage für neue Karten einen wesentlich geographischen Dienst.

Solche Karten, nicht nur solche mit Angabe der Standorte von floristischen Seltenheiten (welche übrigens leicht durch einfache Signaturen eingefügt werden können), sind im Interesse der Verbindung von Pflanzengeographie mit Landeskultur zu erstreben und durch Beigabe besonderer, zusammenfassender Erklärungen in weiteren Kreisen verständlich zu machen. Solche Karten, aus verschiedenen Teilen aller Kontinente in sorgsamer Auswahl angefertigt, würden eine grossartige Illustration zur Vegetation der Erde bilden!

Ch. Flahault hat den Plan entwickelt ganz Frankreich in dem Massstabe 1:200,000 pflanzengeographisch zu kartiren. Ich komme dieser Idee durch Zuhilfenahme der "Übersichtskarten" in 1:250,000 nahe, welche in ihren ruhigen Farben[a] mit grossen Flächen das pflanzengeographisch vollendete Bild in Grundzügen darstellen sollen. Die Formationen selbst können, wie ich mich durch verschiedene Versuche überzeugt habe, nicht gut in kleinerem Massstabe als 1:100,000 dargestellt werden; es bedarf aber auch solcher Blätter nur für besonders wichtige, durch das Zusammentreffen vieler Formationen auf mannigfaltigem Terrain ausgezeichnete Landschaften, wie eine solche im sächsischen Elbtal vorliegt. Eine Formationskarte von Sachsen kann mit den hier vorliegenden vier Generalstabs-Blättern und etwa noch einem fünften von der Höhe des Erzgebirges von Annaberg bis nach Oberwiesenthal und Joachimsthal vollständig auskommen; Kartenblätter in 1:100,000 aus dem weiten Gebiete zwischen Mulde und Elster würden von gar keinem besonderen Interesse mehr sein.

Dafür sollen die Übersichtskarten eintreten, von denen die vorliegende in ihrer Territorial-Einteilung sich an die kleine von mir in Band VI der "Vegetation der Erde" veröffentlichte Karte des hercynischen Florenbezirks eng anschliesst. Aber hier können in dem grossen Massstabe besonders die Höhenstufen der Gebirge (Erzgebirge: untere Stufe bis ca. 500 Meter, mittlere von ca. 500 bis ca. 900 oder 1,000 Meter, oberste über 1,000 Meter) in Abstufungen derselben Grundfarbe angegeben werden, und zugleich die genaueren Eintragungen der Vegetationslinien ganzer floristischer Associationen erfolgen.

Denn solche Karten sind mehr geeignet als diejenigen der ökologisch angeordneten Formationsdarstellungen für summarische Zusammenfassung der Florenelemente, von denen in der näheren Umgebung von Dresden das nordatlantische von Nordwesten, das pontische von Südosten, und das montan-alpine von Süden her zusammentreffen, alle an verschiedenen Standorten: die nordatlantischen Arten (z. B. *Erica tetralix*, *Drosera intermedia*) am Rande der Lausitzer Teiche in Wiesenmooren, die west-pontisch-böhmischen Arten auf den trockenen granitischen oder von Plänerkalk gebildeten Hügeln im Elbtal, und die montanen Arten des deutschen Mittelgebirges mit ihren nördlichsten Standorten in den feuchten Schluchten der Waldtäler.

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[a] Abgestufte Variationen von Grün, Gelb, und Gelbbraun.

Die territoriale Einteilung des ganzen Landes, wie sie im sechsten Bande der "Vegetation der Erde" ausführlich beschrieben worden ist, fasst solche entwickelungsgeschichtlichen Momente zusammen und dient daher als wesentliche Ergänzung für die specielle Darstellung der Formationen: beide Kartenbilder zusammen ergeben erst das richtige floristische Verständnis, zumal auch im Massstabe der Übersichtskarte 1:250,000 noch die Möglichkeit gegeben ist, besonders beachtenswerte Stationen (Seen und Moore, Basaltklippen, die Standorte der pontischen Association auf den die Elbe umschliessenden Felsabhängen) mit grosser Genauigkeit für sich in den gleichen Farben anzugeben, welche dafür unter No. 6, 8, 11 und 12 genannt wurden.

Auch können durch phänologische Eintragungen über den Termin des Frühlingseinzuges oder über die Länge der Vegetationsperiode diese Übersichtskarten nutzbar gemacht werden für den Zusammenhang zwischen Klima und Pflanzenleben der in einem Berglande, wie es Sachsen mit fast 1,200 Meter Höhendifferenz ist, sich immer wieder für wissenschaftliche wie kulturell-angewendete Zwecke in erster Linie aufdrängt.

Den Nutzen dieser gegenseitigen Ergänzung der beiderlei Kartendarstellungen zu zeigen sollte der Hauptgegenstand dieses Vortrages sein; er ist mir nach langen Überlegungen über die Möglichkeiten, unsere mitteleuropäische Floristik auf eine ausreichende kartographische Grundlage zu stellen, immer klarer hervorgetreten.

THE FLORA OF CONNAUGHT AS EVIDENCE OF THE FORMER CONNECTION WITH AN ATLANTIC CONTINENT

By Prof. RICHARD J. ANDERSON, M. A., M. D., Galway, Connaught, Ireland

The flora and fauna of the western side of Ireland differs in some respects from that of the eastern side of the island, and the rocks of the west are among the oldest to be found anywhere; of these by far the most ancient are the granites of Galway and Donegal.

The west of Ireland is separated by a large plain from the eastern side. This plain is occupied by a bog which presents an effectual barrier to the migration of some forms. The union of Ireland with England and of England with the Continent has been regarded as of frequent occurrence in past times. Indeed, the present order of things is the result of comparatively recent changes. An elevation of 100 fathoms would produce again a reunion, while a depression of 100 fathoms would give rise to an inundation of the low-lying lands—the central bog land of Ireland and a considerable part of England. Then, indeed, the highlands at the northwest, northeast, southwest and southeast and west of Ireland would appear as islands in the Atlantic. In the former case considerable tracts would be added to Ireland along the west and south.

EVIDENCE FROM STRUCTURE

Among the most ancient rocks in the world are the granites of south Galway and Donegal. These rocks, of Archean age, participate with the rocks of northeast Scotland and west Wales in making the foundation of the British Islands.

The rocks which succeed these have evidently been derived from a continent lying to the northwest of Ireland, and a shoot of this land seems to have reached from the northeast to the southwest. If one can argue from the characters of fossils found in the adjacent islands, Ireland would seem in its western and northwestern parts to have been the most ancient land in the western part of the Old World. These parts of Ireland may be taken to represent the persistent parts of this very ancient land, altered and crystallized or recrystallized.

No one doubts now that during the coal period and earlier the southern and western part of Ireland formed part of a very considerable continent, which bore the plants that afterwards were washed down into the hollows of countries farther east, forming thus the coal. Hall is of this opinion. The fauna was, indeed, in some parts specialized, and then as now Ireland was remarkable for special varieties of the maiden-hair ferns. These also occur in the Roxburgh beds of Scotland. It may be mentioned that in Norway, Russia, and New Brunswick, as well as Spitzbergen, evidence of a mild climate is found in the early rocks of the period (Old Red sandstone), and Carboniferous rocks are found in abundance in Europe, Asia, North America, Africa (Sahara and Egypt), and in New South Wales. The European continent reached westward, but was broken up, while west Ireland was separated from the eastern part by a shallow sea which deepened and silted up at intervals.

The Permian bowlder bed shows that a northwest land formerly existed.

Ireland was probably connected with an Atlantic land that varied its extent northward and southward during many periods afterwards. It was asserted by Sir Wyville Thomson that Ireland had changed its level very considerably during recent times, and often. He seemed to think that Ireland had been connected with the Continent during Pleistocene times on several occasions, but there is sufficient evidence to show that in recent times this connection did not take place through England. It is certain that local depressions of land occurred in parts of south and central England and France, while Ireland may have been connected with the Continent by way of Scotland or, by an elevated tract, with Spain.

The plants of the drift give us satisfactory evidence of a relation between the flora of the west of Ireland and south Europe which does not exist between the flora of north Ireland and the same part of Europe.

Quite recently Canon Lett has found a species of liverwort in Achill quite different from any yet found in Europe, its nearest relative seeming to be a South American species. It is possible to account for the growth of this species in Ireland in three ways. The most probable seems to be that the earlier connection of Africa with South America may have led to the transportation of the genus, and the modification may have gradually ensued.

Gentiana verna is found in west Ireland, central Europe, the Caucasus, and the Alta Mountains, but not in England. This plant may have reached west Ireland by some land connection, probably Pleistocene, between Ireland and Iberia.

Menziezia polifolia is found in southwest France, and Asturias, in Spain, and in Connemara. The plant has had much repute in the past

because of its traditional virtues. The plant is called St. Dabeoc's heath, and is considered to have a "charm" in preserving the honor of those who gather and wear it.

Arbutus unedo is found in southern Europe and west Ireland, but not in Britain.

Erica Mackaiana is found in Connemara and Asturias; *Erica ciliaris* in Spain, Portugal, and the west of Ireland; *Erica mediterranea* in southern mountainous Europe and Galway; *Erica vagans* in the Mediterranean region, Cornwall, and west Ireland. *Dryas octopetala* is more widely distributed in the British Isles, one of its best stations being Galway. *Dryas* is found in North America, northern Asia, and northern Europe; *Orchis intacta* in Galway and in the Mediterranean region.

There seems to be some evidence that certain Atlantic islands were connected with Iberia by means of North Africa, and the nature of the fauna of south England seems to show that the animals there were like those of Africa. Recent investigations have established the fact that like conditions of climate and similar animals were found in Ireland (Scharff). It is not easy to prove beyond doubt that paleolithic man flourished in the highest degree in Ireland, but that conditions prevailed very favorable for men of that period can be easily established. Fir wood is very abundant in the bogs, and so is oak. The first was the wood of paleolithic man and the latter of the neolithic type.

The presence of bears in some caves in the west of Ireland, and their remains found in bogs, show that *Arctos*, at least, was abundant. It is indeed very improbable that west Europe, including south England, should have had paleolithic forms and that Ireland should have been altogether uninhabited.

Tradition points to a series of peoples who lived in Ireland from time to time, and the later groups correspond to the neolithic and bronze types.

The ancient types of horse and ox still persist, owing to their viability, which the long hair and basal tuft at the base of the tail tend to establish for the horse. *Equus caballus celticus* has no chestnuts on the hind legs. In this respect and the tail tuft the Celtic pony resembles the Iceland pony (*Cossar Ewart*).

Differential characters are also to be sought in the invertebrata of the inland regions of Connemara. Probably west Ireland, Wales, west France (Normandy), and the greater part of Spain were land during the Upper Chalk, Eocene, Miocene, and Pliocene times.

THE AMERICAN RANGE OF THE CYCADOFILICES

By DAVID WHITE, U. S. Geological Survey

[Abstract.]

Although petrified material showing internal structure is extremely rare in the Carboniferous of the eastern United States, carbonized remains and impressions representing all the cycadofilic genera whose fronds are known are found in this country. Of the medullosan genera *Neuropteris* and *Alethopteris* selected for examination as to distribution, it appears on a preliminary review that over 60 per cent of the European species are present also in this continent. Comparison of European specimens will doubtless considerably increase this percentage. It is suggested that the character of the fructifications lately reported for *Neuropteris* offers an explanation of the remarkable facility of distribution which these genera seem to have possessed.

The stratigraphic range of the cycadofilic genera in the Upper Carboniferous (Pennsylvanian) of America offers extremely few points of difference from that of the same genera in western Europe. The same is probably true of the Lower Carboniferous (Mississippian) types, though our floras of this period are very little known.

Announcement of the discovery was made, with exhibition of specimens, of seeds found in organic union with the foliate pinnæ of *Adiantites*, previously regarded as a fern. This genus, which accordingly is referred to the Pteridospermeæ, is the third type in which seeds more or less distinctly gymnospermic in characters have been definitely correlated with cycadofilic fronds. If all the species of the genus *Aneimites* are, like its typical group, generically indistinguishable from *Adiantites* of authors, the Cycadofilices go back, in America also, to the base of the Carboniferous. The relatively high organization of the fruits of *Lyginopteris* and *Neuropteris* creates a new problem in the realm of paleobotany, viz, the origin of the Cycadofilices. The antiquity of the latter compels us to look for their heterosporous ancestors near the base of the Carboniferous and in the Upper Devonian, a period concerning whose pteridophytic floras we have, after all, disappointingly little knowledge.

ORIGIN OF FRESH-WATER FAUNAS

By THEODORE N. GILL, Washington, D. C.

[Abstract.]

Every degree of transition is existent between animals inhabiting the salt waters and those of the fresh waters, but in almost every polymorphic class are segregations, of at least family value, practically confined to the fresh water. Before true generalization respecting distribution can be attained a sound morphological basis must be secured.

The most remarkable aggregate of fresh-water forms is exemplified by the ostariophysal fishes. This group includes the Characinids, Cyprinids, Gymnotids, and catfishes, representing about 3,000 species and a number of families. Tropical South America contains a much greater diversity than any other continent, and all the important families except the Cyprinoideans, and several that none other possesses.

If paleontology is invoked, little assistance is obtained for the comprehension of these facts. The main feature evolved is that in the Eocene a couple of the families (Silurids and Cyprinids) were nearly as specialized as now. The significance is evident. The forms can not have originated in the Tertiary, as has been claimed. The most likely source of origin and primitive development was South America or some neighboring land now submerged. The time of origin must have been much earlier than would be generally admitted, at least as early as the Jurassic, and possibly as early as the Carboniferous epoch. The later origin of the Cyprinids, from a precharacin type, may have taken place in or near southeastern Africa.

ORIGIN OF THE DEEP-SEA FAUNA

By DR. A. E. ORTMANN

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The fauna of the deep sea has been regarded by some writers as representing a very old element of the earth's life, since it was recognized that some ancient types have survived in the depths of the present oceans. On the other hand, others have denied this fact, and believe that this character of antiquity is not very evident among the deep-sea fauna.

Both views are supported by facts. But, instead of generalizing too rashly, the proper way is to say that the present deep-sea fauna seems to be composed of different elements which have a different origin, and became members of this fauna at various times during the history of the earth.

Recalling to our mind the chief physical character of the deep sea, which is found in the peculiar temperature conditions prevailing all over the bottom of the great ocean basins, the temperature being very uniform and near the freezing point, and then considering the development of temperature conditions upon the earth as a whole, we arrive at the following conclusions:

A cold deep sea can not be thought of at a time when there was no cold water at all in the littoral districts of the oceans. The cold water of the deep sea is derived from the cold littoral waters of the poles, and the existence of a steady circulating flow has been made very probable from the shallow polar waters down into the deep sea and along its bottom toward the equatorial latitudes, where, at certain points, the water ascends again. At a time when the poles were not sufficiently cooled to permit the formation of sea ice such a circulation of ice-cold water must have been impossible. What, then, the actual temperature conditions were is hard to imagine, but possibly they were similar to those prevailing at present in isolated deep-sea basins (as, for instance, the Mediterranean Sea), and we may safely assume that, whatever they were, there was no ice-cold water at the bottom of the sea.

Thus it is clear that only the introduction of ice-cold temperatures at the poles rendered the present condition of the deep sea possible, and we are confronted with the question at what time, geologically speaking, this change was brought about.

There was a time when it was almost generally believed that climatic differentiation of the earth's surface goes very far back in time, namely, as far as the Jurassic period, and possibly further. This view, however, has been largely abandoned now, at least in so far as it is not probable any more that the littoral waters of the poles were ice cold in Mesozoic times. The introduction of this latter feature into the earth's climate very likely falls into the Tertiary time. Of course, the cooling was a gradual one, and at present it is impossible to fix more accurately the date when the first ice formed at sea level at the poles.

This climatic change must have affected not only the temperature conditions of the deep sea, but also very decidedly its fauna. Before it the deep sea must have contained a warm-water fauna, while at present it possesses a most pronounced cold-water fauna.

This cold-water fauna of the present time may have a different origin. We can imagine that part of the old warm-water fauna became adapted to the new conditions, and, indeed, it seems that certain elements now represented in the deep sea actually belonged to this category, being clearly types of life that go back far into Mesozoic times. On the other hand, it is also imaginable that certain other forms of life immigrated into the deep sea after the cooling of the waters had taken place—that is to say, in Tertiary times—and the center of radiation for this element naturally is to be sought for in the littoral waters of the poles. Also this element has been clearly recognized in many cases, certain deep-sea forms of life being most closely allied to forms existing in the cold littoral waters near the poles.

But another question remains with regard to the latter element. The fauna of the two poles is not identical. As the present writer has pointed out elsewhere, we have reason to believe that either polar fauna had a different origin, the north-polar fauna being a derivate of the old Mesozoic Mediterranean, the south-polar fauna of the old Pacific fauna. The first developed along the shores of the northern continents, while the second must have had its original home on the shores of the antarctic continent. We know positively that there is a strange element among the littoral fauna of the southern extremities of the continents, differing entirely from the arctic fauna, and we can not but think that this is a remnant of the old Tertiary antarctic fauna.

The above considerations give us a threefold origin of the present deep-sea fauna:

1. An ancient Mesozoic (or pre-Tertiary) constituent, which is

derived from a transformed part of the old warm-water fauna of the deep sea, adapted to the changed climatic conditions. It is clearly autochthonous.

2. A more modern, immigrant, Tertiary constituent, which came from the north-polar littoral waters, and immigrated into the deep sea together with the cool water (or after it had cooled). This element goes back to an old pre-Tertiary stock that lived in the warm littoral waters of the old Tethys (Mediterranean Sea), but as a cold-water fauna is not older than Tertiary.

3. Another Tertiary element, corresponding to the second one, but belonging to the south pole, and which finally is to be traced back to the warm waters of the old Pacific Ocean of pre-Tertiary times.

The above considerations are intended merely as suggestions, to which attention ought to be paid in future research of the deep-sea fauna. The first element has already been clearly recognized in some cases. Polar groups, in general, can also be pointed out among the deep sea fauna, but not much attention has been directed to the question whether they came from the north pole or from the south pole. But I have no doubt that it will also be possible to distinguish these two elements, if properly investigated. I may add that it seems to me that by far the largest number of the polar elements in the deep sea has been furnished by the antarctic littoral fauna, while only a small part came from the north pole. But this needs further research.

Finally, it remains to be investigated whether there is yet a fourth source for the deep sea fauna, namely, the littoral regions of the tropical parts during Tertiary times. It does not seem very likely that any tropical warm water forms immigrated directly into the cold deep sea, but the possibility can not be denied, and we ought to be on the lookout for such cases.

RÉPARTITION GÉOGRAPHIQUE DES ANIMAUX

Par G. GRANDIDIER, Paris, France

[Abstract.]

M. Grandidier donne communication aux membres du congrès d'un passage d'un de ses ouvrages actuellement en cours d'impression relatif à la distribution géographique des animaux. Il expose comment depuis l'époque à laquelle l'histoire naturelle a cessé d'être une science purement descriptive, un grand mouvement de curiosité a entraîné les esprits curieux de connaître les manifestations actuelles de la vie à la surface de la terre et de rechercher dans son passé ses origines et son développement.

La zoologie a surtout profité de cette tendance, car il n'est, pour ainsi dire, pas de jour qui n'amène de nouvelles découvertes non seulement dans les contrées peu explorées, mais même dans le sol de nos pays civilisés tant de fois fouillés. On a exhumé de la sorte des faunes dont l'étude approfondie a montré les relations intimes qui les rattachaient soit aux animaux des périodes géologiques antérieures, soit à la population zoologique de notre globe. C'est ainsi que quelques-uns des vides qui existaient dans la série animale se sont trouvés comblés, mais ce ne sont là que des fragments d'une chaîne que par la paléontologie seule nous ne pouvons espérer reconstituer au complet; car beaucoup de formes de transition nous resteront inconnues, les conditions de leur disparition n'ayant pu leur permettre de se conserver. Mais si l'idée de la transformation des êtres vivants n'est pas démontrable par les seules recherches paléontologiques, il est peut-être une autre voie par laquelle il faudrait aborder le problème pour en hâter la solution, c'est l'étude minutieuse de la distribution géographique des animaux. Quoique cette question ait été étudiée par d'éminents savants comme Agassiz, Huxley, Wallace, Milne-Edwards, dont les travaux resteront la base de toutes les recherches sur ce sujet, il semble qu'il y ait lieu maintenant de les reprendre et, le cas échéant, d'en combler les lacunes par les récentes découvertes zoologiques ou paléontologiques. Il serait en effet intéressant, avec les données nouvelles qui nous sont parvenues en si grand nombre depuis un quart de siècle, de synthétiser

ce que sont devenues les formes animales dans le temps et dans l'espace, en faisant abstraction des limites étroites et factices qu'ont entraîné les mots espèce et genre qui, dans la nomenclature et malheureusement dans l'esprit de tant de travailleurs, ont tenu une place si prépondérante.

De même que la continuité d'existence d'un organismé dans la série des âges géologiques constitue pour les zoologistes un fait très important, de même la présence en des lieux divers d'une même forme animale plus ou moins modifiée par le milieu qu'elle habite est pour le naturaliste une constatation des plus intéressantes. Et, en effet, même si le mode de répartition des espèces animales sur les divers points de la surface du globe n'est pas indépendant de l'origine de ces mêmes espèces, il n'en faut pas moins considérer la puissance transformative des agents ambiants, climats, conditions biologiques, et selection naturelle, qui amènent dans des limites de variabilité plus ou moins grandes la transmutabilité des types zoologiques.

M. Grandidier expose ensuite comment on peut expliquer la présence d'animaux de la même espèce dans des lieux très éloignés les uns des autres et séparés par des barrières infranchissables. Il se range à l'opinion de Milne-Edwards, qui attribue à une souche unique tous les animaux de même espèce en quelque lieu qu'ils se trouvent. L'extension plus ou moins grande des représentants d'un même type est en rapport avec deux circonstances: 1° le développement plus ou moins grand de leurs facultés locomotrices par rapport à la configuration du sol, et 2° la durée du temps écoulé depuis le moment de la première apparition du type auquel ils appartiennent.

En général le mode de distribution des animaux à la surface du globe, quelles que soient les régions observées, témoigne de l'extension progressive des représentants d'un même type autour d'un même lieu, d'un foyer d'irradiation. Les exceptions à cette règle sont plus fréquentes chez les animaux aquatiques que chez les animaux terrestres, et parmi ceux-ci on peut se rendre compte que ces cas exceptionnels sont inégalement repartis entre les différents groupes zoologiques, que dans la classe des reptiles, et plus particulièrement parmi les sauriens, ainsi que dans la classe des insectes, ils sont beaucoup plus nombreux que dans celle des mammifères. Il est facile de voir dans ces faits une relation entre l'ordre d'apparition des animaux sur notre globe, c'est-à-dire leur degré d'antiquité, et la localisation plus ou moins grande des types zoologiques.

L'auteur insiste ensuite sur l'importance des migrations zoologiques et termine en disant qu'il estime que c'est par colonisation que la majeure partie de la terre se serait peuplée.

THE POST-GLACIAL DISPERSAL OF THE NORTH AMERICAN BIOTA

By CHARLES C. ADAMS, University of Michigan, Ann Arbor, Mich.

1. INTRODUCTION

During the last few decades there has been a remarkable accumulation of data on the geographical distribution of the extratropical North American biota. In addition to the facts themselves there has been a great advance in those allied sciences which throw some of the most important side lights upon distributional problems—the physiographic and geographic histories of definite areas.

It is of interest to know that the leading factors in this increase in our data have been the surveys by our National Government, especially the Biological Survey of the Department of Agriculture, State surveys, and the great activity of our larger museums, although specialists and amateurs must not be overlooked.

While among many groups there have been notable advances, yet or others our knowledge is still very incomplete, and must apparently remain so, because of the immensity of the field and the scarcity of workers. Here even the preliminary organization of data is yet to be made. The recent advance, then, in distributional work has been largely due to the great increase in the amount of data.

The next general stage of advance which we may expect to follow this stage of rapid accumulation of facts is that of their explanation or interpretation. At present this phase of the subject is much confused by the babel of opinions as to the relative importance of various influences controlling distribution. There are several points of view, and each worker is keen to the influence of certain factors. It is to be hoped that this diversity of opinion will lead to a period of discussion, enriched by many suggestions and discoveries of relations previously unnoticed. Such a period would certainly hasten the correlation and interpretation of much miscellaneous and imperfectly organized data.

It is to one phase of the subject of faunal interpretation, and the dynamic aspect of the historic factor in particular, that special attention is directed in this paper. That the historic factor is a real

one is very generally recognized, and yet in spite of this fact it is difficult fully to realize that the present distribution which we see is largely an effect of past conditions, the cumulative result of many factors, and not controlled altogether by the conditions of the present environment. To estimate properly this factor it becomes necessary to reconstruct the successional relations and the past conditions, and thus to see how each stage has prepared the way for the following one. We must reconstruct the past, for this is as essential in geographical distribution as is the restoration in the mind of the paleontologist of the soft parts of the fossils he wishes to interpret.

Some phases of this subject are much simpler than others, just as the history of one region may be much simpler than that of another. From the biological standpoint this is certainly the case with that part of North America which was repopulated during the decline of the Wisconsin ice sheet.

To understand fully the return movement to the glaciated region it is necessary to know the time relations of the various Pleistocene deposits of fossils, as during that time there flourished a variety of forms that are no longer members of our present fauna. The mastodon, mammoth, peccary, camels, tapirs, native horses, and many other forms were then abundant. But as this phase of the subject is unfortunately in a very chaotic state, little help can come from this source at present. Yet there are certain facts derived from these fossils which are very significant. For example, the occurrence in Pleistocene times (Hay, 1902; Hatcher, 1902)[a] of such arctic types as the walrus in Virginia and South Carolina along the Atlantic coast, the musk ox in Pennsylvania, West Virginia, Kentucky, Indian Territory, and Iowa, and the reindeer in New Jersey, Pennsylvania, Kentucky, and Iowa certainly shows that an arctic climate once reached far to the south. Although limited, this information clearly suggests the general extreme southern limit reached by arctic types during the ice age. As the Wisconsin ice sheet was not the maximum one in southern extension, these arctic types, in their last migration, in all probability did not start from this extreme southern limit, but from some zone north of it. This gives us an approximate starting point in eastern North America of the post-Glacial return of life to the glaciated region. From the Great Plains westward the ice sheet did not extend far to the south in the United States, so that the return movement in that region began much farther north, near the Canadian boundary. At present, as has been said, paleontological facts do not greatly aid in understanding the early post-Glacial northward extension of the biota. But there is another source of information to which we may appeal, and that is the affinities or relationships of the biota south of the ice margin. This makes it necessary to take into account the general conditions of

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[a] See references on page 637.

life in North America south of the Wisconsin ice margin, and hence the areas of preservation which must have existed in North America during the ice age.

2. BIOTIC PRESERVES DURING THE ICE AGE

Repeated glaciation had almost sterilized the northern part of the continent. Whence, then, came the life now occupying that region? Many of the problems involved in a reply to this question can not be answered at present, but others may be, in an approximate manner. Much exploration remains to be done in northern Asia before we can hope to answer certain questions on those elements in our fauna and flora which have decided Asiatic affinities. But when we consider the more characteristic American elements, a much greater degree of definiteness may be secured. From our knowledge of the distribution and conditions of life of the present biota it seems that while the northern part of the continent lay deeply buried under the mantle of the Wisconsin ice sheet there existed, in all probability, south of the ice margin three distinct belts of life (Adams, 1902 b).[a] At or near the ice margin, and perhaps occupying only a narrow transcontinental belt, was the tundral or barren-ground biota. Below this came first stunted trees and shrubs, and farther back coniferous forests forming a transcontinental belt, but composed of two distinct types, an eastern and western one. Below this, in turn, came a third belt of still less homogeneity; in the East it was composed of deciduous forests and their associated fauna, while in the West it was made up of plains and desert types of life.

With these conditions in mind let us now turn to a more detailed consideration of the various elements which go to make up these belts of life and attempt to follow some of the dynamic phases which this biota has shown since Glacial times. The fundamental idea in following these dynamic changes is that we have belts of similar physical conditions migrating northward. Thus a definite trend is given to the environment. This fact can not receive too much emphasis. Just as when studying the littoral fauna of a pond or lake it becomes necessary to bear in mind the dynamic tendency of this littoral zone--that is, its tendency to move inward toward deeper water—so, in a similar manner, to understand the dynamic changes in life areas or zones we must bear in mind the dynamic tendencies in such areas (Adams, 1902 a, p. 126). Nor is this limited to climatic and topographic influences alone; it includes organic factors as well. It is necessary to keep such dynamic tendencies in mind also when attempting to follow the relations and movements of these three belts in their post-Glacial migrations.

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[a] See list of references on page 637.

The three belts or waves just mentioned were composed of such distinct elements and have had such varied histories that they demand separate treatment. The wanderings of these different types since Glacial times is likely to make the application of geographic names confusing (see map). The members of the first zone or wave (tundral type) have spread from the Ohio Valley to the Arctic Sea; the members of the second wave have moved from much the same southern

Map showing present location of the five biotic types and the area invaded by them in post-Glacial times. The transverse line marks the southern margin of the last (Wisconsin) ice sheet.

limit to Hudson Bay; but the third wave, composed of the southeastern and southwestern biota, has been relatively stationary. The first two waves entered the territory they now occupy largely from the south, although we usually think of them as completely boreal forms,

and as tending southward in their dispersal. Turning now to a brief consideration of the primary characteristics of these elements in the biota and beginning with the one which invaded the glaciated region first we have the following order of succession:

FIRST WAVE

1. TUNDRAL OR BARREN-GROUND BIOTA.—This element of the return movement exists to-day in the North beyond the tree limit and as relicts farther south upon mountain summits. This is a circumpolar type and has few constituents that are peculiarly American. Its original center of dispersal may have been farther south near the centers of ice accumulation or, as Dixon (1895, p. 298) has suggested, in the elevated regions of the Tropics. In either case it has had a very nomadic existence.

As there is reason to believe that the ice did not completely cover all the northern land, some of this type flourished there, in all probability, even in Glacial times, as, for example, in the Point Barrow region of Alaska, where Nelson (1887, p. 27) has noted the distinctly Siberian affinities of the biota. This factor suggests that the life of this region is an overflow, perhaps in pre-Glacial or Glacial times, from unglaciated arctic Siberia.

Migration and dispersal routes.—The first wave biota has apparently reached its present location by a northward Glacial and post-Glacial migration, and has been supplemented by certain Glacial relicts, from Alaska in particular, as has been suggested, while in more recent times some additions have been received from Asia and Greenland, as has been shown by Stejneger (1901, 1903) for the wheatear. The migration route of the western birds of this species points to India by way of Alaska, and the eastern ones to Africa by way of Greenland. Probably the latest paths followed northward were along the mountain chains, where occasionally colonies have lingered in favorable conditions upon mountain peaks.

SECOND WAVE

2. NORTHEASTERN BIOTA. The second wave was of the biotic type now represented by the northern transcontinental coniferous forest belt. But this belt was not homogeneous from east to west, and the eastern element in this wave will be considered first. On account of its wanderings, this wave, as in the case of the first, can not be geographically defined in the East as a center of dispersal without danger of confusion. Although this biota reaches its best development at the present time in the Northeast, yet it is only a relatively late arrival in that region. For eastern North America this was the "second wave" (Adams, 1902 b, p. 309) to pass north after the retreating arctic climate attending the decline of the Wisconsin ice sheet. The region

now occupied by this biota contains abundant lakes and peat bogs, and is poorly drained. It is covered by coniferous forest, but of a very different type from that found in the Rocky Mountain region, as has been shown by Rydberg (1900, pp. 871–873). Here the very characteristic bog-plant society reaches its best development, as shown by Transeau (1904). This is the region of fur-bearing animals, and there are very few reptiles and amphibians. On the west this biota swings north of the Great Plains in Canada to the Rocky Mountains, and then north into the Mackenzie basin.

Migration and dispersal routes.—The northeastern type of biota has moved from about the latitude of the Ohio Valley north to its present position. Certain elements have apparently pushed far northwest to the Rocky Mountains, to the Mackenzie basin, and even overflowed into the Yukon Valley; the reverse route, in all probability, was followed by certain Asiatic forms into America. This westward and northwestward dispersal has tended perhaps to overemphasize the transcontinental distribution of these northern types, and shows how the determination of faunal areas based primarily upon the present conditions tends to obscure the compositeness and diversity of origin of their constituent elements. This biota reaches its greatest southward extension along the Appalachian Mountains. Laggards of this and the barren-ground type form the "boreal" islands, when surrounded by the life of the following wave. These occur not only upon mountain tops, in bogs, and on sand dunes, but also in certain deep lakes, where the "abyssal" fauna shows very decided northern affinities, and clearly suggests that they are Glacial relicts.

3. Western center of dispersal.—In the West we recognize a second center of northward migration. It is represented by the biota of the Rocky Mountains and the Pacific coast region. Its great extent, even in Glacial times, south of the ice margin, and its present occupation of the field, allows this biota to be geographically defined as the western center of dispersal. In contrast with the region dominated by the eastern part of this wave, the western branch occupied a high mountain country. It was a coniferous forest belt, but, as has been mentioned, was of very different type from that of the Northeast. The present flora of the Rocky Mountains and the coast region is of the same general type, as shown by Coville (1893, pp. 29–31) and Rydberg (1900, p. 871), although the climatic conditions are quite different in several respects. It should also be recalled that much of the recent botanical work has been done in the Rocky Mountains near the Canadian border, so that later studies in the southern Rockies may, to some degree, lessen this apparent uniformity. These facts do not favor the idea of transcontinental unity of the coniferous forests, but show that the direction of geographic origin, the adaptations of the biota to mountain conditions, and proximity are factors

which must be reckoned with in understanding the post-Glacial repopulation of the Northwest. The same factors also suggest that the usually accepted transcontinental distribution of the fauna may be overestimated. At least it is very evident that many of the present characteristic animals of the western mountains are lacking in the relatively low eastern Appalachians. Such a relation may have been closer in the past than it is at present, as is suggested by the occurrence of the pica (*Ochotona*) in the Pleistocene of Pennsylvania, although now in North America it only occurs in the western mountains. There is also in the West a great increase of Asiatic types, in addition to certain native elements. The mountain goat (*Oreamnus*) and bighorn (*Ovis*) are representative mountain forms of the West, but lacking, even as fossils, in the East. This is also true as to some invertebrates, as for example the butterfly genus *Parnassius*, the crawfish *Potamobius*, the west coast *Unionidæ*, and certain *Arionta*-like land shells, are quite distinct from eastern types. The composition and affinities of this western biota require much more study before its true position can be determined. In marked contrast with the northeastern biota, this one has long been bounded on the south and east by an arid climate.

Migration and dispersal routes.—With the exception perhaps of Glacial relict colonies in favorable spots along the Pacific coast, and in the unglaciated parts of Alaska, the biota of the Pacific coast and Canadian Rockies must have pushed into this region primarily from two directions in post-Glacial times. To a limited extent there was an overflow of the northeastern biota, but the great bulk of the population came from the Rocky Mountains and Pacific coast region south of the Canadian border. Dispersal must have been carried on under great disadvantages, on account of the topographic difficulties. But this biota, on account of its proximity and early invasion of the region, had manifest advantages over the later arrivals. That a great wave of life moved north along the mountains from this western center is very apparent from the present affinities of the life of the region extending from southern British Columbia to Alaska. The primary highways were probably the mountains themselves and a narrow coastal strip, now largely submerged. These lines of dispersal are to-day migration routes for birds. Bishop (1900, p. 50) has shown that a large part of the Yukon Valley birds winter in western United States, and this clearly suggests their western origin.

The extensive distribution of certain forms in northwestern North America, and their occurrence as well in the Northeast, has suggested the northwestern origin of such forms. From the present standpoint it seems more likely that most of these northwestern forms have been derived from the western center of dispersal, from which they spread northward, and overflowed into the northeast. It also seems that the

northern biota in general has had a northern rather than a southern trend to its dispersal.

The Alaskan region, in addition to its Glacial relicts, was apparently repopulated in part by a northward invasion from the western center of dispersal along the mountains, by a double invasion from Asia (Stejneger) north and south of the Stanovoj Mountains, and by contributions from the northeastern biota.

It also appears that some members of the mountain biota of the Canadian Rockies were driven northward into unglaciated Alaska as the ice spread from the cordilleran center of ice accumulation.

THIRD WAVE

4. SOUTHEASTERN CENTER OF DISPERSAL.—The region occupied by the southeastern type of biota lay largely south of the territory invaded by the ice, and its biota has therefore been relatively stable in its geographic position when compared with the extensive migrations of the first and second waves. As to-day, during Glacial times this biota was bounded on the west by the arid plains. This is a region of low plains and plateaus, the higher mountains within this area still retaining the second wave types as Glacial relicts. It is probable that the first wave type never reached in abundance so far south. The climate of this southeastern center is equable and there is abundant rainfall. The dense deciduous forests furnish favorable conditions for animal life. This area has been important not only as a region of preservation, but also as a center of origin. Here is found the best development of the deciduous forest and the most characteristic features of the land and fresh-water shell life of North America. This has also been the center of distribution of several vertebrate types and also for certain plants, but as this area has been discussed elsewhere (Adams, 1902 a) only brief mention will be made here of the characteristic features.

Migration and dispersal routes.—With the retreat of the ice this biota formed the eastern element of the third wave. It moved north and northwest behind the coniferous forest zone. But as this biota was relatively stable, its center of dispersal can be definitely limited to southeastern United States east of the Great Plains. This stability therefore makes the dispersal routes of more importance than the migrations of the biota as a whole, as the spread of this biota has apparently been influenced more by the normal increase of a densely populated area than by a great change in physical conditions, which was such a dominant factor farther north.

The primary routes for the land forms were the Coastal Plain and its valleys, the Appalachian plateaus, and the Mississippi and tributary valleys. For the aquatic types, the Tennessee and Mississippi rivers were the leading highways. From the upper end of the Coastal Plain

a limited number of land forms pushed up the Hudson, and even worked west via the Mohawk Valley to the Great Lake region. From the Mississippi numerous tributary valleys were followed—the Ohio, Wabash, Illinois, and Missouri—and thus this biota radiated rapidly. It even invaded the Great Plains along eastward-flowing streams, especially along the Missouri River.

The second wave types reach their most southern extension along mountains, while this third wave reaches its most northern extension along valleys, not only to the north, but also upon the arid plains of the Northwest.

5. The Southeastern Center of Dispersal.—The area occupied by the southwestern biota was largely far beyond the ice margin, and like that of the southeastern, was relatively stable in its geographic position. At present this type is represented by the life of the arid Southwest, including the Great Plains, the Great Basin, the central valley of California, and the Mexican plateau. It is a vast region of arid plains, desert plateaus, and mountains, subject to great climatic extremes. In spite of the severity of the conditions of life the biota is quite varied, and many forms are abundant. Attention has already (Adams, 1902 b, p. 121) been called to the importance of this center, and too much emphasis can not be placed upon its importance, not only as a center of distribution, but also as the region of origin of the arid North American biota. It seems equally evident that before a reliable estimate can be made of this biota it must be carefully compared with that of the arid regions of South America and of Asia. The life of the first and second waves in the post-Glacial migrations contained many forms not peculiarly American, but the southeastern and southwestern elements of the third wave show much more individuality. The southeastern center has certain endemic elements in its flora and fauna, yet several other types have their affinities duplicated in eastern Asia, and thus its individuality is somewhat lessened. On the other hand the southwestern center, although it shows some Asiatic duplication, does not appear to be so marked. So far as known to me no one has made a detailed comparison of the arid types of the two continents.

The distinctness of the southeastern and the southwestern centers is frequently overlooked or confused. And this is especially liable to be the case when allowance is not made for the influence of local conditions upon the occurrence of certain southwestern types which have overflowed into the eastern center. This brings up the following question, which, as will be seen later on, clearly emphasizes the importance of habitat study in geographical distribution. In estimating biotic areas, how much weight should be given to the occurrence of forms dependent upon limited local conditions? A bare census gives no idea of the relative weight of the units recorded or the degree

of their representativeness. The importance of such a study in a proper estimate of local conditions has been repeatedly suggested in attempting to determine the relations of these two centers. These relations have suggested that perhaps biotic affinities can be more easily and safely determined by habitat and biotic associations than primarily upon a faunistic or floristic basis. This would mean that the ecological relations rather than the taxonomic affinities should receive greater attention. It should be noted, however, that this view does not in any way belittle the importance of taxonomic work in distributional studies. But it is sufficient at this place simply to call attention to the ecological aspect of the subject.

But to return to the consideration of the Southwest. The vegetation of this arid region is composed of grasses on the plains, and cacti, agave, yucca, and many other types of desert vegetation in the more arid places. Reference need only be made to the recent paper of Coville and MacDougal (1903) for the characteristic features and the literature of this flora. The fauna is equally peculiar and interesting. This is the region where prairie dogs, spermophiles, pocket gophers, pocket mice, wood rats, and kangaroo rats are found, and where horned toads, rattlesnakes, and many other reptiles reach their greatest variety and center of abundance. This has been the center for many other forms as well. Certain crawfishes (Ortmann, 1902) have originated here. Many groups of insects are also peculiar to this region. The bees of the genus *Perdita* are very abundant, and, as Prof. T. D. A. Cockerell informs me, are very characteristic, only a few species occurring east of the Great Plains (Cockerell, 1898). The beetles of the *Tenebrionidæ* are very abundant. The ant lions, *Myrmeleonidæ*, here reach their greatest development in variety and abundance. The fish fauna is limited and peculiar. The fishes of the Rio Grande have Mississippi River affinities, while those of the Colorado River show much endemism, as is noted by Meek (1903). Of its 32 species, only 10 are known to occur elsewhere.

Migration and dispersal routes.—As only a small part of this southwestern center was invaded by the Glacial ice, its geographic position has been relatively stationary. Since the Ice Age, however, there has been considerable overflow to the north. Starting in the Southwest this biota has spread northward along both sides of the Rocky Mountains and has invaded an arid region, where it found conditions to which it was evidently well adapted. Even glaciated portions of British America were reached, on both sides of the mountains, by these hardy forms of life.

Other plants and animals have spread from the Southwest to the Southeast, where, on account of the varied conditions of life, they have been able to flourish. This, for example, is seen in the case of yucca, lizards, and pocket gophers. These forms have been able

to find favorable arid local conditions in the Southeast, as in the pine barrens and on dry hillsides.

These arid types find their eastern extensions upon the dry uplands, interdigitating with the southeastern types which frequent the moist valleys. They reach their extreme eastern extension, in abundance and in association, upon the prairies of Wisconsin, Illinois, and northern Indiana. But with the clearing away of the forests this eastward advance has been greatly hastened.

The aquatic life of this center has communicated with the Mississippi River, as shown by the Rio Grande fish fauna, but that of the Colorado River has been isolated to an exceptional degree, and has developed a remarkable individuality.

3. SOME FACTORS IN BIOTIC INTERPRETATION

In a previous paper (Adams, 1901) the writer has discussed the relation of base-leveling processes to habitat differentiation and their influence upon the successional relation of the faunas correlated with the degree of topographic development of a region. Although the fauna was mentioned in particular, these factors influence the entire biota in a similar manner. During the process of degradation of the land there is a definite and orderly succession of conditions through which the habitats pass—the brooks become larger streams, the lakes and ponds become drained, the uplands are lowered, etc. Not only does the location of the habitats change, but also their relative positions and extent. On account of the great influence which topographic conditions exert upon habitats, it is possible to find very diverse biotic conditions even in a relatively small area. Students of local faunas and floras frequently comment upon this diversity, and, although these facts are often noted, yet but little attention is given to them because of their seeming chaos. This apparent mixture or confusion is often due to a total disregard of the habitats and the associations of the forms in them. That this occurrence is, as a rule, quite definite and orderly may be seen by reference to the example of certain southeastern types that are evidently of western or southwestern origin—the yuccas and pocket gophers. These are types from an arid region, and it is important to note that when they invade a moist region they occupy the relatively dry situations—the pine barrens, sandy or rocky places—to find the conditions most nearly approaching those of their original home. Such colonies form "islands" of arid types, surrounded by those correlated with greater moisture. The significant fact here is the definiteness of the conditions in which they occur. Again, this same tendency is shown in the extreme northward extension of the southeastern biota along protected valleys, and even far out upon the Great Plains. Similarly, in southern Michigan certain characteristic members of the southeastern biota enter the State at the southeastern

and southwestern corners, rather than along the southern border, because valley highways enter the State at these corners. Apparently this same route into southeastern Michigan has been utilized by certain forest trees, insects, birds, and doubtless other southern types which have also invaded extreme southwestern Ontario. Such facts might be indefinitely multiplied, but these clearly show that invading elements tend to enter a region, not only at a definite place, but also tend to remain in definite habitat associations and conditions even after they have once entered a region. This habitat individuality causes more or less isolation of the various elements invading a region and furnishes an index to their direction of origin, and at the same time reenforces the idea of the regularity of their field relations. To be sure this definiteness becomes more or less blurred and indefinite along tension lines, but it is not confusing when considered with the proper perspective.

It is quite evident that the kinds of biota frequenting similar habitats must be largely different in distinct biotic regions. This may be seen by a comparison of the same habitats in regions occupied by distinct biotic types. Thus, if a comparison is made between the shell life frequenting the margin of an isolated pond in Michigan and that occupying the similar habitat of a sink hole pond in East Tennessee, a marked dissimilarity is noticed. In the northern pond there will be an abundance of shells belonging to the genera *Limnæa* and *Physa*, while in the southern one these genera will be poorly represented or entirely absent. If a similar comparison is made between the shells found in rapidly flowing brooks from the same regions, it is seen that the southern stream abounds in shells of the family *Pleuroceridæ*, a family poorly represented in the north. The *Limnæidæ* are northern in their distribution; the *Pleuroceridæ* are characteristically southeastern. The same general relations hold for the vegetation; in the Southeast there is the deciduous forest and in the Northeast a coniferous one.

On account of the unique character of the life occupying the same kind of habitats in distinct biotic regions, there is in these regions a different succession of forms attending changes in the topography, climate, or any other factors which may influence habitats. Thus, the succession of ecological associations is likely to be similar, even in very distinct regions, when similar processes and conditions are at work, yet the biotic components —the families, genera, or species, etc.— are likely to be quite different. Such relations as these mean that from very diverse kinds of life there tends to be formed de novo, or by association, certain ecological types which become correlated with certain habitats. Thus certain habitat types have originated many times independently. For example, the fresh-water fauna was not formed all at once. This environment has been independently and

repeatedly invaded by very diverse animals, and from diverse habitats. The same is equally true of the minor fresh-water habitats, such as that of the littoral zone or the rapid water of a brook, etc. The same is equally true of land habitats, such as caves, deserts, and many other situations whose biota has been derived from all possible directions. It is thus evident that there are two fairly distinct classes of succession in a given biotic region, the adaptational one, in which the ecological aspect is prominent, and the hereditary one, in which the taxonomic or hereditary aspect receives emphasis.

From the above considerations of habitats and their biota, their successional relations and their convergent habitat and ecological tendencies, we are led to a very natural question: What is their bearing upon migration and dispersal centers? This relation is very close, and unfortunately is too often completely overlooked. If in the study of the life of a given region practical recognition can be made of the above-mentioned relations, which are involved in the study of the origin of the biota of given habitats, there will result a very desirable geographic perspective. Such a perspective will greatly aid in the determination of the relative influence of the factors of the environment. As the habitats of many plants and animals change with geographic range, it is very desirable to take advantage of this variation in estimating the relative influence of different elements in the environment. In this way we may hope to distinguish between the local and geographic conditions, influences which are easily confused. It is primarily their reflex effect upon geographic distribution, and especially upon biotic interpretation, which interests us at this time, a subject which can not be separated from a consideration of the relative influence of environmental factors. Habitat studies not only throw important light upon geographic origin of biotic elements, but also upon the conditions of life determining routes of dispersal, and these are often very important elements in biotic interpretation, for it seems at present that it is along this line that we may expect, in the near future, some of the most rapid advances in the solution of distributional problems.

4. SUMMARY AND CONCLUSION

In summarizing we may note that recent advances made in the study of the extra-tropical North American fauna and flora have been primarily due to the rapid accumulation of data. In the near future rapid advances along the line of explanation and interpretation of these facts may be expected. As the present distribution is in part an effect, it is therefore necessary to take into account certain past conditions. Very important among these factors have been Glacial and post-Glacial influences upon this region. These geological changes have had a great influence on the biota, both on account of the won-

derful changes in the physical conditions of life attending the decline of the Ice Age and also on account of the definiteness given to the dynamic tendencies by this environment. In the attempt to determine the affinities and interrelations of the present biota too much emphasis can not be placed upon this definite dynamic tendency, and upon the sources and routes followed by the life on its return to the glaciated region. This returning biota followed, in all probability, a definite successional relation, and was composed of three general belts or "waves," concentrically distributed south of the ice margin. The first one was of the barren-ground type; the second was represented by distinct eastern and western coniferous forest types, and the third by the biota of the Southeastern and Southwestern States. The first wave was of transcontinental extent; the second, while coniferous and transcontinental, was composed of two distinct types—the eastern, represented by the biota of northeastern North America, and the western, represented by that of the Rocky Mountains and the Pacific coast. The northeastern biota overflowed to the north and northwest into the Mackenzie basin to the Rocky Mountains, and a few forms even into the Yukon Valley. The northwestern biota spread from the Rocky Mountain and Pacific coast regions in the United States northward to British Columbia and Alaska. The third wave spread from the southeastern center of dispersal northward to the conifers and westward to the Great Plains. From the southwestern center the life spread northward on both sides of the Rocky Mountains into Canada, and only stragglers spread eastward into the humid Southeast.

Further light is to be thrown upon the interpretation of these centers of dispersal and their biotic types by taking into account the successional relation of the biota, as correlated with changes of the environment. The habitat relations of organisms show that they do not occur promiscuously mixed, even within a small area, but that their relations are orderly and definite. In addition to the general successional relation attending changes of the environment, attention is called to the different kinds of organisms in different biotic regions which make up this succession. This habitat uniqueness of the biota in different regions favors the independent formation or association of similar habitat types from very diverse kinds of biota.

With these sources of post-Glacial supply, their routes of dispersal, and their definite habitat relations fresh in mind, it becomes very evident that these factors must greatly influence our interpretation of life areas. These facts strongly suggest that the present conditions of life can not be expected to fully explain the present distribution, and clearly emphasize that the historical factor must be dynamically considered.

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EVIDENCE IN FAVOR OF THE FORMER CONNECTION OF BRAZIL AND AFRICA, AND OF AN ORIGINALLY ANTARCTOGÆIC LAND MASS

By ALPHEUS S. PACKARD

In this essay the author has kept two propositions in view: (1) There are at present two chief assemblages of animals on the globe, i. e., Arctogæa, or the northern fauna or center of origin of types, and Antarctogæa, or a chief southern assemblage quite distinct from Arctogæa. (2) What are now the three realms called Notogæa, the Ethiopian realm, and Netogæa, were formerly connected and inhabited by types peculiar to the land mass lying in general south of the equator.

Whether the southern continents of South America, Africa, and Australia were once connected with an antarctic land has already been discussed, and to this theory the author has nothing new to offer.

The present essay is confined to a theory of a former land connection between Brazil and West Africa along or near the equator.

It is well known that toward the end of the Miocene Tertiary there were widespread changes in the physical geography of the earth. These elevations and subsidences may have profoundly affected the Atlantic basin. The great orographic changes which prevailed in the regions north of the equator could scarcely have left unmodified the ocean bottom in the southern hemisphere.

The suggestions which have been thrown out by some geologists that the ocean in Paleozoic times was shallower than now, and that the present ocean depths--the "deeps" of oceanographers—are situated off areas of elevations or mountain plateaus, are significant in this connection.

The formation, late in the Miocene, of the Isthmus of Panama; the separation of Europe from America by subsidences, of which Greenland, Iceland, and the Hebrides are relics; the subsidence by which in later times Asia became separated from North America, where now is Bering Straits, are occurrences which are generally believed to have been very probable. Why may not such profound changes have been

paralleled by similar changes in the south Atlantic Ocean, both in the equatorial region and perhaps about the South Pole?

As early as 1862 Andrew Murray pointed out the existence of Brazilian elements in the Coleoptera of Old Calabar, and in 1870 he claimed that the Atlantic was once traversed by stretches of dry land which united west Africa with Brazil, and Patagonia with the Cape of Good Hope. Additional evidence has been offered by Gill, Ihering, Kobelt, Ortman, Scharf, and others, from facts in the distribution of land and fresh-water plants, earthworms, Arachnida, Mollusca, Crustacea, Dipnoi, bony fishes, Amphibia, reptiles, and birds.

The new facts I have to offer are taken from the distribution of Lepidoptera. An extensive group of large African moths (Bunæinæ) are nearest allied to the Neogæic group Ceratocampidæ; still stronger resemblances exist between a Chilean genus of another group, and an African subfamily (Urotinæ). Another large and important family (Hemileucidæ), now chiefly confined to South and Central America (Neogæa), has representatives in the Ethiopian realm. Within this group are several highly specialized genera which occur in tropical and southern Africa.

There are, in short, five groups of South American Syssphrigine moths alone which have representatives in western or southern Africa, the latter so highly specialized as to suggest their primitive origin from Neogæa.

Several groups of butterflies also afford parallel facts.

Our main reliance is on the fresh-water and land invertebrates and lower vertebrates, since the present distribution of birds and mammals was determined by changes which took place after the Eocene Tertiary, when Africa and South America had become widely separated.

If we examine the *Challenger* maps and the map given by Chun we shall see that, in the mid-Atlantic, between Cape St. Roque and Sierra Leone, for a distance of about 2,000 miles, there is a plateau extending southward from the telegraph plateau of Cyrus Field which rises above the general level of the ocean bottom to a level of from 6,000 to 9,000 feet below the present level of the ocean. On each side are depths of from 2,000 to 2,500 fathoms. Between Cape St. Roque and Sierra Leone, besides this submarine plateau, there are three small plateaus between St. Paul Rock and Sierra Leone, rising to within from 6,000 to 9,000 feet of the surface; and also the little island of Fernando Noronha. There were thus probably three stepping stones between the Brazilian and the west African coasts, i. e., the two islands just named and the two small elevations between St. Paul Rock and Sierra Leone, these being nearly the same distance apart. Far to the south, in about latitude 16°, rises the island of St. Helena out of a depth of from 2,000 to 2,500 fathoms. Also, in about latitude 20.5°, east of Rio de Janeiro, is the island of Trinidad.

It thus appears that it would require an elevation of the ocean bottom of from about 1 to 2 miles between Brazil and Sierra Leone, Africa, to form a more or less continuous land connection between the two continents apparently sufficient to account for the spread or intermigrations in pre-Miocene times of plants and animals between what are now two widely separated areas.

Such an oscillation, or series of oscillations, taking place in mid-ocean is of no greater extent than we suppose must actually have taken place at different geological epochs in other regions of the earth.

We should not be too much influenced by the hypothesis or dictum of the permanency of the ocean basins. Indeed, still holding to it in a modified form, the hypothesis of an extensive land connection between the continents of Antarctogæa involves no greater amount of elevation than most probably occurred between what is now North America and Europe.

HABITS AND NORTHERN RANGE OF THE RESIDENT BIRDS OF POINT BARROW

By MIDDLETON SMITH, U. S. Department of Agriculture

During the occupancy of the meteorological and magnetic station of observation at Point Barrow, Alaska, 1881–1883, by the International Polar Expedition, there were observed 51 species of birds. Of these, only three are resident—the snowy owl, the willow ptarmigan, and the rock ptarmigan; the others, with the exception of a few stragglers, are annual visitors.

Snowy owl (*Nyctea nyctea*).—The snowy owl is a resident of all the northern part of Alaska, both interior and insular. At Point Barrow it is abundant in the spring and summer along the coast, where its favorite food—the lemming—is plentiful. It is, however, the most difficult of the bird fauna of the Arctic region to capture, because of its excessive shyness and watchfulness. This shyness seems to be a characteristic of the bird throughout its northern range. Captain Smith, a well-known whaler, relates that he had seen as many as fifty of these birds perched in view at one time along the abrupt coastline of the Arctic, in the vicinity of Cape Lisburne, so shy that it was impossible to secure a single bird. Although seen and pursued at Point Barrow by our party almost daily for several months, only two snowy owls were taken. One of these afforded much sport. He was in the habit of appearing daily at about the same hour and settling himself, in plain view of the station, upon the opposite bank of the lagoon, out of range, however, of our Winchesters. He was often pursued, sometimes by one, again by two members of our party, with rifle or shotgun, and often fired at with rifle at long range. Mr. Guzmán would take his daily exercise in going out to capture this owl, but would as regularly return baffled. He was at last secured by me with the assistance of an Eskimo youth, who at my suggestion semicircled to the edge of the lagoon and then moved directly toward him. While the owl's attention was thus attracted by the movement of the Eskimo, I stole to cover in a ravine, over which I rightly judged the bird would fly. The shotgun range, however, at which I opened fire was so great that the owl flew fully an eighth of a mile before drop-

ping. He plunged headforemost into a pool of water, completely burying his head in the black loam. The Eskimo remarked that the owl after escaping death from the rifle was so ashamed of being wounded by a shotgun that he took a header into the water and mud, and tried to bury himself from sight.

The range of the snowy owl is not confined to the land surface. It has been seen on floating ice far out at sea. Instances are known of its coming on board of ships as much as 75 miles from the nearest point of land. Lamont mentions seeing it 180 miles from Lapland, the nearest coast.

The snowy owl is found on the northern shores of Europe and Asia, as well as America. Almost the entire Arctic region, so far as known, is its home. The highest latitudes reached by Arctic explorers have scarcely exceeded the bounds of this hardy bird. The Nares expedition discovered it nesting on Grinnell Land, in latitude 83° 33′ north, where a nest, "a mere hollow scooped out of the earth, on the top of a rise in the center of a valley," was found, containing 7 eggs. Greely relates that the snowy owl bred abundantly in the vicinity of Fort Conger, and as many as 15 or 20 fine young birds were raised in 1882, and kept until approaching winter compelled their release. After a great lemming season the owl is said to nest in Lapland, and in northern Norway also, usually choosing for this purpose a hilltop or hillside. The eggs are from 5 to 8 or more in number, and the measurement is about 57 by 45 millimeters; the form is roundish oval, the color white, and the shell is of fine texture.

The favorite food of the snowy owl, as heretofore observed, is the lemming, which are so numerous at times and so sudden in their appearance, that they were fabled to rain down from the clouds. This bird feeds also on ptarmigan, sea ducks, duck hawks, stranded fish, and occasionally Arctic hares. The owl hunts in the daytime, and at morning and evening twilight. In its rapid and powerful flight, it strikes ducks and ptarmigan on the wing like a falcon, seizes lemming from the ground, and fish from the shallows. Its method of capturing an Arctic hare, as related by an Eskimo to Nelson, is by planting one foot in the hare's back and stretching the other foot back and dragging its claws on the snow and ground; at the same time using its wings to hold back, by reversed strokes, until the hare becomes exhausted, when it is easily killed. One of these owls was seen, as Richardson relates, to fly over a cliff on the lower Mackenzie and carry off a full fledged duck hawk in its claws. It crossed the river to the farther bank, where it alighted on the shore to devour its prey. The parent hawk followed, uttering loud screams, and, darting down with great rapidity killed the owl with a single stroke. After this summary act of vengeance the falcon returned to its nest.

Like numerous other birds this great white owl, as Nelson observes,

figures largely in the mythological tales of the northwestern Eskimo, one of which in particular is an interesting account of the way in which man learned the use of various implements by the experience of a metamorphosed owl.

According to Alaskan folklore, a little Eskimo girl was changed by magic into a bird with a long beak, and became so frightened that she sprang up and flew in an erratic way until she struck the side of a house, flattening her bill and face so that she became just as these owls are seen to-day.

Willow ptarmigan (*Lagopus lagopus*).—Willow ptarmigan are never plentiful in the immediate vicinity of Point Barrow. They are, however, to be frequently seen in pairs during the breeding season, but are wild and difficult of approach. In the winter their tracks on the snow are always to be seen, but the birds themselves seldom. The winter plumage is as white as the snow itself, and the presence of the bird is generally known only by its flight. Upon several occasions I walked within 20 feet of where they were sitting in depressions made by them in the snow, and it was not until I had passed and for some cause stopped that they took fright. Other members of the party had a like experience, approaching even nearer, and not observing the birds until through fright they flew from their resting places. This may account for so very few having been seen near the coast in winter. They are abundant inland along the river banks where the willow shrubs are plentiful, the buds of which constitute their favorite food.

As a food bird we found the willow ptarmigan poor; the meat, though tender, is dry, tasteless, and insipid. In some parts of Alaska, nevertheless, this bird is one of the most important sources of food supply of both Eskimo and Indian, being snared and shot in great numbers, especially during the winter, and not infrequently being the only defense these natives possess against the ever recurring periods of scarcity and famine. During the migratory season many thousands are caught in snares (nooses of sinew) hung on branches of brush, which are arranged in small clumps and set in a line along the ice at places where the ptarmigans usually pass. The birds, in their migration, seeing these brushes, follow them, and coming as they do in great numbers, the captured birds can scarcely be taken out fast enough to make room for others to be snared.

The love antics of the male willow ptarmigan during the period of mating are very striking, and the pugnacity of the bird is even more so. In selecting his mate he goes through a series of grotesque capers, with wings and tail spread out, tail thrown over the back, neck ruffled, head either thrown back to meet the tail feathers or else stretched along the ground, and, while uttering a hoarse, barking croak, he bounds into the air and sails and flutters round and round in a circle; then, alighting, he rushes toward his favorite one as though he intended

to run over her, but stops when near to repeat the fantastic performance. "Woe to another male which thinks to coax away the object of his choice." The intruder has only to be seen by the other when a battle royal takes place. They seize each other by the comb or feathers and pull and jerk until the one or the other becomes exhausted. The intruding male is nearly always vanquished, as the other would die before deserting his chosen mate.

The Eskimos take advantage of the pugnacious habits of the male birds and capture great numbers of them by means of a decoy—a stuffed male ptarmigan with a sharpened stick inserted into the body and securely fastened thereto—and a small square net having pegs attached to two of its corners to fasten it to the ground. With the bird decoy and net the native starts out in search of a mating pair, which, when heard or seen, he approaches, fastens the net to the ground, and sticks near it the decoy, which the live male soon perceives and rushes to it to give battle; and, while pulling and tugging at it, the native jerks a string which throws the net over both birds, thus capturing the live one. Even after the net is over the bird, he does not desist from fighting. A male will sometimes advance to the decoy while the native is yet setting the net, and in some instances he is so courageous as to advance when the decoy is held only at arm's length.

The willow ptarmigan is perhaps the most interesting species of the few genera of the arctic fauna which inhabit the northern portion of Alaska. Its plumage in winter is pure white, and in spring and summer it takes the color of the moss-covered tundra, thus forming one of the most characteristic accompaniments of the scenery of arctic Alaska.

The food of willow ptarmigan during winter consists of mosses and lichens and the past year's twigs of the willow and alder or other bushes. The flesh then is dry and insipid. As open weather advances they find berries that remain frozen the entire winter, and tender grass shoots also. In spring and early summer they eat the tender, swelling buds of the willow, of which, as heretofore observed, they are especially fond, and the buds, also, of other bushes. The flesh then acquires a bitter taste. During late summer and early fall they feed largely on berries, which are to be found growing almost everywhere on the level treeless area (tundra) of northern Alaska. The flesh of the bird is then better than at any other season of the year.

Rock ptarmigan (*Lagopus rupestris*).—The rock ptarmigan is even a less plentiful resident of Point Barrow than the willow ptarmigan, but it is abundant within the Arctic circle, and is found on the hills and higher ground along the entire coast region of Alaska. During summer it frequents the hills and mountains, but when cold weather sets in returns to the lower elevations and seeks shelter under the brush-bordered ravines and furrows marking the slopes. The willow

ptarmigan keeps more strictly to the lower and more level parts of the country, frequenting during the summer the open stretches of moss and grass covered tundra, but in winter is mostly found in the deeply bordered water courses and ravines.

Like the snowy owl, the rock ptarmigan has a high northern range. The English expedition found it in latitude 83° 06′ north. Greely considers it a winter habitant of Grinnell Land. Lockwood took one in latitude 83° 03′ north, on the north Greenland coast, and found traces of this hardy bird in latitude 83° 24′ north, at Lockwood Island.

With the exception of the range, the habits of these two species of ptarmigan are about the same. They are rapid flyers and swift runners, but the rock ptarmigan is the more rapid flyer, and its power of flight is stronger, being sustained for a much longer period. The flight is very regular, and on this account these birds, when startled, are easily shot. Both are handsome birds, the rock ptarmigan being the more beautiful. The male of the latter species, about the beginning of the mating season, has assumed the summer plumage of "rich chestnut, fulvous, and black markings on the neck, head, back, and edges of the wings, the rest of the body being white, which, by contrast with the other colors, makes a magnificent plumage. The female has less chestnut, black, and white plumage and more of the fulvous to render her less conspicuous." The male at this season seems less pugnacious than its congener.

The nest of the rock ptarmigan, as observed by Nelson, is carelessly constructed, being composed of a few grass stalks or blades, with the few feathers that fall from the breast and abdomen of the female. The eggs, which number from 9 to 16, often lie, near the completion of incubation, on the bare ground, surrounded by a slight circle of grass stalks that have apparently been kicked aside by the mother, impatient of her task. The nest of the willow ptarmigan is usually on a hillside or under the shelter of a small solitary straggling bush, and in both material and construction is similar to that of the rock ptarmigan, and the number of eggs is about the same. The male of both species assists in rearing and feeding the young, which, however, as soon as hatched follow the parents, and when of the size of our Bobwhite are able to fly. The chicks are to a great extent insectivorous, consuming great numbers of spiders that are to be found on the warm hillsides. Seeds are also a favorite food of the young.

A notable feature of these two species of ptarmigan is that they annually shed their claws as regularly and completely as they molt their feathers. Another distinctive characteristic is that they not only have their legs densely covered with feathers, but also their toes and the soles of their feet as well, thus giving to the foot the appearance of a hare's foot, whence the generic name *Lagopus*, from two Greek words signifying "hare foot."

The ptarmigan are as much at home in the snow-covered regions of the frigid North as are the web-footed birds in the waters of the sunny South, their plumed feet enabling them to run over the snow without breaking through the surface. The snow is their favorite resting place. They delight in rolling in it. They scratch down to the mosses and lichens on which, in the absence of more accessible food, they feed, and they form holes in it wherein they pass the night or seek shelter from the storm.

The ptarmigan are remarkable, as heretofore observed, for the seasonal changes of plumage, the colors of which harmonize perfectly with nature, thus minimizing the danger of attack from natural enemies. The abundant plumage and thick down, possessed alike by the snowy owl and the ptarmigan, enable them to brave the inclemency of a climate that would be fatal to any bird less amply protected.

The resident birds of Point Barrow—the snowy owl, the willow ptarmigan, and the rock ptarmigan—inhabiting as they do the desolate and unbroken solitude of the far North, furnish the student of ornithology the most strange, weird, and intensely interesting study of bird fauna found anywhere on the globe.

THE CONDITIONS OF MAN'S ORIGIN

By Dr. LEONIDAS CHALIKIOPOULOS, Athens, Greece

Every organism is adapted, by the kind of integuments of its whole body, to the influences of its surroundings and to those of other living beings; by the shape of its body and its limbs and the way of its locomotion, to the form of its food; by the degree to which its organs of sense and the nervous system are developed, to the difficulties of finding and procuring its food and to its self-preservation.

TROPICAL CLIMATE AND THE ABSENCE OF HAIR

The scanty hair covering the human body points as a striking feature to a uniformly warm, partly damp climate as man's primeval home, since here a thick hair covering would not only suppress the necessary expenditure of the body's heat and cause therefore an excessive secretion of perspiration, but would also absorb the moisture, and thus not only prevent cooling by evaporation of sweat, but also the rapid running off and drying of rain, and would thus act equally unfavorably either by extremely heating or cooling the body. The loss of hair was therefore a fundamental condition for the possibility of strong muscular exertion and consequently of labor.

The hair covering the head was preserved, since on the skull no muscular actions required the expenditure of a surplus of developed heat; it protected at the same time the most valuable part of the body against the sun's rays and against injuries, just as the eyebrows serve to keep off sweat and rain from the eyes, the most sensitive organs. On the other hand, the beard covering the masculine cheeks—a distinctive sexual mark—is only poorly or not at all developed in tropical races, and is first acquired in cold climates. The need of the inhabitants of hot countries to remove, if possible, all hair (as we like to do in summer), together with the unpleasantness and unhealthfulness of moist clothing, which in cold climates artificially compensates the hair covering, but in tropical heat is of course felt to be superfluous and disagreeable, proves the great efficiency of nudity in a hot and damp climate and its development in adaptation to such a climate.

The stiff but only slightly heat-conserving hair of the animals of the

tropical steppes may serve partly as a protection against some kinds of insects (although it directly favors others), but serves chiefly as an agent of protective coloring. Monkeys, it is true, do not need any protective coloring, as they can be seen only close at hand on their high trees; but for them a heat protection is as important as protection against insects, so that on the one hand for them the necessary expenditure of heat in consequence of muscular exertion is much easier, while on the other hand the heat protection is much more important than that of larger animals. This is best shown with tropical pachydermata, which, being densely covered with hair while living in the north, did not require here on account of their size either a heat or color protection, protecting themselves against insects by the thickness of their hairless skin.

FRUIT NOURISHMENT AND STRUCTURE OF THE BODY

THE GRASPING HAND AND WALKING FOOT

While the grain-picking birds as well as the leaf- and grass-eating mammals can easily and directly, with beak or teeth, take hold of their food, since it is small and ready to be swallowed, and while the carniverous animals need only catch their living prey and hold it to the ground with their claws in order to tear it to pieces and devour it, the food of the fruit-eating animals requires not only the climbing of trees or the digging of roots from the ground, but also some preparation, as the fruits are generally large or are inclosed in hard shells. Therefore the feet of the grain- and plant-eating animals (birds and mammals) answer solely the purpose of more rapid locomotion; while the limbs of beasts of prey had to be shortened in order to adapt them for use as claws to grip their prey. By this their rapidity in running was considerably diminished, a fact of but little importance, as, on account of the size and nourishing quality of their food, captures needed to be made only at long intervals.

For the fruit eaters an increased flexibility of the whole body, and especially of the limbs, was required. This was wanted to a still greater extent the more the animal took to living exclusively on trees. The ends of the much-elongated limbs had to be transformed and to become more flexible, because they were not only to be used for taking hold of the branches, but also for preparing fruits for swallowing. But since the two front extremities are free for seizing only when the animal sits upright, this posture and manipulation formed the first art the fruit-eating animals had to learn. It has been acquired by different species of mammals, from the rodents up to the monkeys. While with the former, which live chiefly on the ground, only slightly articulated walking or scraping feet were wanted, such as could only together carry the fruit to be eaten, while preparing and chewing it

was left to the teeth, with the latter the mouth was partly freed from the preparatory labor. As soon as the one hand was able to take hold of the fruit the other, thereby becoming disengaged, could prepare it. The former capability has developed even among fruit-eating birds, such as the parrots, which can carry food to their beaks with a single claw. The most advanced fruit eaters, the monkeys, are best adapted by the structure of their grasping hands and feet to moving on trees, where they have to take hold of the branches as well as of the fruits.

As in man the hands only are thus adapted, while his feet physiologically equal those of the sometimes upright-walking bear, we may suppose that he developed from some animal form which, like the bear, moved chiefly on the ground, and for this purpose used only the hind legs, while the fore feet were adapted entirely to climbing trees and grasping fruits.

The unequal length of the limbs in man and monkeys speaks in favor of the original division of labor, for in moving on trees long legs and short arms are a hindrance, but on the ground are very useful. That the peculiarities of the human limbs were developed from those of the monkeys while changing the habit of living on trees to that of living on the ground seems to be probable, for the big apes, too, which by their weight are compelled to live on the ground, have still preserved this proportion. Their grasping feet do not show any signs of transformation, however, because they walk only on the edge of their feet and on the backs of their bent fingers, keeping, when on the ground, unsuitably the same position of the hand as when moving on trees.

The development of man's animal prototype, so much deviating from that of the monkeys, must have taken place under quite different conditions, since otherwise one of the two forms, having the same way of subsistence, would not have been well adapted to its environment. The monkeys in dense tropical forests are confined entirely to a life on trees, since the immense growth of vegetation makes movement on the ground extremely difficult; on the other hand, the fruits on the trees are not easily seen from beneath; but even if these two things had been possible, it was more practicable to swing in the trees from one fruit-laden branch to another than to climb each of these high trees from below. On the other hand, the human form could develop only in countries where the dry seasons, occurring once or twice a year, cause a diminished growth of vegetation, not suppressing so much the higher animal life, and where in the less dense woodland or park-like forests the greater distance between the trees necessitated climbing them, while at the same time movement on the ground was not so much prevented by creepers and underbrush. Finally the human walking foot was here just as well suited for climbing the smooth trunks of the chief fruit trees—of palms and banana

trees—as was the grasping foot of the monkeys, while the concave inside might appear as an adaptation to the necessary pressure of the inside to the trunks when climbing trees.

The two groups of the most advanced tree fruit-eating animals would thus represent the descendants of a common, corporally more man-like than ape-like ancestor, with shorter and less perfect walking legs and grasping arms. One of these branches, the human, could combine in the light tropical forests the two ways of life, living on trees and on the ground, and thereby preserve the advantages of the two; while the other, the monkey family, had to adapt itself in the impenetrable forest to a life in trees, getting thereby more one-sided and less apt for further development.

THE MOUTH

The plant-eating animals either continuously plucked the soft, small leaves with their front teeth, simultaneously swallowing them because the parts of plants to be taken at once were so small that a previous collection of them in their ruminant stomachs was necessary, or chewed and swallowed them at once when the quantity of food to be reached was large enough; on the other hand, the beasts of prey used their jaws and teeth far more for taking hold of their prey and tearing it to pieces, scarcely chewing. So in the former animals long rows of molars had simultaneously to be active in a long, narrow, almost tubular mouth, while in the latter a wide, but short mouth, opening as large as possible, with numerous canine teeth at its entrance, answered the purpose best.

A very different opening to the alimentary canal was wanted in fruit-eating animals. They could not at once swallow their chief food, the nuts, like ruminating animals and beasts of prey, nor could they chew them, like other herbivorous animals, but were obliged first to crack them. This would have detained them too much while they were gathering their food, and would also have been too difficult on the trembling branches. They were therefore obliged to store them somewhere, and the entrance to the alimentary canal was the fittest part of the body for transformation into a kind of food pocket. The cavity of the mouth adapted itself to this purpose not only by means of its height and width, but also by its skin covering, the cheeks and lips; that purpose was best attained by narrowing the opening of the mouth as much as possible. But the fruit-eating animal did not want more incisors than were needed to bite off a morsel from a large fruit; and the molars were not required to be numerous on account of the concentrated food; therefore its sets of teeth fit exactly into the arched shape acquired only in the human mouth, not showing any gaps because of the absence of projecting canine teeth. This shape was also most suitable for the reception of liquids, as it permitted sipping by

means of pointing the lips, and prevented at the same time the accumulating juice of the masticated fruits from flowing from the mouth.

The tongue, which had, corresponding to the palatal cavity, to adopt a short and thick shape, had to be active only within. Here it was essential that it should forcibly assist in preparing hard and dry fruits, while in herbivorous animals it was able, by its length, roughness, and strength, to tear off leaves and herbs, and in beasts of prey its length, thinness, and flexibility made it suitable for the sipping of fluids. With these two groups of animals the tongue is also indispensable for their bodily health; in the most advanced fruit-eating animals it was, also for that purpose, replaced by the hand.

The great differences between the mouths of men and animals reflect, like their limbs, their different surroundings as well as their habitual way of living. Primeval man wanted smaller cheek pockets for collecting his food than the monkeys did, as he could gather fruits by shaking them off the trees or throwing them to the ground, and then calmly devour them or carry them away. While the monkeys were obliged to crack the nuts with their teeth—needing, therefore, much stronger jaws, chewing muscles, and teeth, since on high trees they were not able to apply any other mechanical means—primeval man had nothing to do but crack them between stones, scarcely to be found in dense forests. Therefore, his chewing organs were less used and became much weaker, while, on the other hand, his mouth and its opening could get smaller, since it was no longer expected to crack large and whole nuts. Of still greater influence in this respect was his chiefly soft and juicy food, as in the light forests of his home there grew, no doubt, more juicy fruits, like pineapples or bananas, than hard-shelled nuts, which, to the contrary, were the chief food of the monkeys in their home—the dense forests.

The course of development of the two originally closely related families of monkeys and men is best illustrated by the fact that young monkeys and men, repeating an earlier stage of phylogenesis, resemble one another more than old ones, since in the former arms and chewing apparatus, in the latter legs and brain, thrive faster. Just as the great difference of their limbs depends on the dissimilarity of their necessary locomotion, so the difference of the ape's and man's mouth points to the peculiar alimentary conditions of the countries, with different climate, to which they adapted themselves, and as the difference in limbs was the cause of man's material culture, so in the difference as to the form of the mouth lay the foundation to his intellectual culture by his capability to speak—a power quite peculiar to him. For only the most perfect form of the alimentary canal's entrance, the mouth, with its peculiar arching, with tongue, cheeks, and lips—among mammals only acquired in man, among the birds, insofar as this is possible, in parrots—was alone suitable for producing articulted speech.

The question why other animals do not possess this ability is often answered by pointing to their lack of intelligence, although it is primarily due to mechanical reasons. How could man speak if he were restricted only to the motion of his vocal chords, jaws, and epiglottis, like animals? He might sing and croak like a bird, bark and howl like a dog, perhaps utter some other sounds, perhaps produce a few vowels and consonants, but hardly more than that.

Man's speaking power was produced partly by the extraordinary mobility of his short and energetic tongue and lips, partly by the short and light lower jaw, partly by the closed and rounded rows of his teeth, so that a cavity may be produced in the mouth, as in a very complicated pipe, that varies according to the position of the tongue as related to the palate or teeth. How, therefore, could any of the mammals have developed a human-like articulated language, as they had neither such a sounding cavity as the mouth, nor could they have toned it so differently by tongue or lips?

Since the development of any section of the central nervous system regulating the special use of some part of the body could not occur before the special use had originated, and since both gradually developed together, therefore the power of speech, due to a certain part of the brain, could develop only in man, while, of course, in animals this power was wanting, for they lacked one of the most important factors of the higher faculties of thinking—thinking by forming abstract ideas, the conception of which is based in the first place on language.

FRUIT NOURISHMENT AND CONSCIOUSNESS

THE SENSES

The sense of touch in herbivorous animals is, according to their grasping organs, the lips and tongue, of limited efficiency, since it can only extend to the roughness, softness, or adhesiveness of those parts of the plants immediately to be eaten. With beasts of prey the forepaws serve for touching things out of curiosity, for discriminating degrees of hardness and humidity; but the chief sense of touch is here also situated in the whiskers, serving as feelers, and in the tongue. With fruit-eating animals, on the other hand, it became the task of the grasping limbs to examine the corporeal world. For not only their food, the fruits, demands a very different treatment according as the shells are hard or soft, glutinous or prickly, and according to size, best ascertained by the sense of touch, but also their movements the grasping of different branches, thick or thin, smooth or slippery, in a delusive foliage, especially during nighttime—would be impossible without it. And in taking care of the body, too, the touch situated in the fingers had to take the place of that of the tongue, the latter having become unsuitable to the purpose. Here the power

of touching all parts of the body and the development of the most movable limbs were already attained, under the supervision and for the supplementation of sight. In man it could finally develop to the most perfect degree, inasmuch as the hands, being of free locomotion, could always be disposed of for the purpose of touching, and could attain, by this restriction to soft and only temporary touching, a much greater sensitiveness. This faculty of discriminating superficial qualities, as well as the ability to perceive the form of other bodies by touching, tended to make the conception of them, introduced already by the sense of sight, much more distinct and correct. These functions were, therefore, of the greatest importance, not only for the development of technics, but also for the peculiarities of human consciousness.

The sense of smell is in herbivorous animals acute, but little differentiated, as it possibly serves only to avoid poisonous herbs in the search of food, not particularly supporting propagation within the flock, and is chiefly of importance in protecting them against their enemies. In beasts of prey it is the most acute, partly to find out their prey, partly to facilitate propagation in their lonely life. On the other hand the sense of smell has in fruit-eating animals qualitatively gained what it quantitatively lost in sensitiveness, since they often have to find fruits by their odors and to distinguish edible from injurious ones; for their sexual life it was but of little importance.

Hearing shows a similar development, reaching a great sensitiveness to the slightest noise in mammals, which most needed this protection, an ability to distinguish different notes in singing birds, and a more perfect perceptive faculty for different simultaneous or rapidly successive spoken sounds in some birds, and, of course, in man. It seems that in every animal a differentiation of hearing occurs parallel to its own ability to produce certain noises, tones, or sounds.

The organs of sight with herbiverous animals are not required to be directed to the food during its almost mechanical and prolonged gathering, but must at the same time overlook very extended plains for protection against enemies, power which is acquired by their lateral position at the expense of the acuteness and stereoscopic qualities of binocular seeing. With beasts of prey the chief requirement is an acute seeing of outlines at limited distances at the expense of an extension of the range of vision. This quality, also proper to fruit-eating animals, had in them to be so adjusted as to make difficult movements on trees possible and to enable the discovery and preparation of fruits. This point was also of the greatest importance for their intellectual life, because it allowed them to concentrate attention on one object, and their attention was not so easily diverted by other indistinct impressions. These two facts caused a more acute and more lasting impression of sensation, by means of which not only

their thinking in visual conceptions became clearer and more extensive, but also their sounds—their language—the development of which, where the conditions were given, depended chiefly on the degree of this discriminating faculty.

THE INTELLECT

While the herbivorous animals are busy with their easy but tedious task of taking food during a large part of the day, and while the beasts of prey must lay in wait a long time until they succeed in taking hold of their fleet-footed prey, the fruit-eating animals are more favorably situated, because fruits (such as nuts) are more nutritious, and may be had quicker and in large quantities. They may, therefore, live together sociably and on good terms, because the peculiarity of their domicile—the trees—prevents their crowding together. The difficulty in moving and the great variety of food compels them to act individually, whereas the uniform distribution of food over the ground favors the habit of living in herds with herbivorous animals, wherein each animal need only accommodate itself in its actions to those of its neighbor, while the difficulty in getting food compels the beasts of prey to avoid one another, since everyone of them will rather despoil its neighbor than catch the prey itself.

Among beasts of prey the mother can not be accompanied by her troublesome young on her difficult hunting excursions; neither can she supply them later with the necessary quantity of food, so that the father has to take a considerable share in feeding them, and on account of this condition a large number of less-developed young ones can be brought up. In opposition to this monogamy there is among herbivorous and fruit-eating animals living in flocks no established and lasting pairing, because with the former the young ones could almost at once accompany their mother on her search for food, and because with the latter they could be carried by her; therefore they had to become more developed and less in number.

Since the fruit-eating animals are least occupied with the search and gathering of food, part of them spend their leisure hours lazily and sleeping during daytime, like the sloths; others again, like the monkeys and parrots, are extremely lively and busy, enjoying their sociable life, while playing, an occupation to which those belonging to the two classes requiring the other kinds of food can give their time only in their youth, since their later life is either entirely taken up by the search for food or is lonely.

But playing causes actions which frequently deviate from those imitative ones necessary for searching food, and therefore requires more reflection, so that play, therefore, apart from the advantage it confers by exercising the attention and the faculty of mental combination, may also be useful to animals in a more practical respect.

But in the first place the obtainment of food itself stimulates reflection, since fetching a fruit from a thin branch, cracking of big nuts, or getting the juice from a narrow cavity, indeed, the discovery of such food in general, is by itself more difficult and complicated than feeding on grass, which wants nothing but perseverance, or than the catching of prey, requiring chiefly acute senses and physical strength. But these faculties were superfluous for fruit-eating animals, since they needed neither to espy the fruit from a distance nor to scent it, nor to get it by special power of speed.

The instruction necessary to enable the young ones to discover and obtain their food—and like instruction is not needed with animals feeding on grass, and can be practiced with rapacious animals on the prey brought home - was especially favored with the fruit-eating ones by the fact that the young, always carried about by its mother and clinging to her, could take the mother's movements for a guide and attentively follow all her actions; then it could by itself, or stimulated by her, begin to imitate her, whereby it could, of course, gradually acquire and practice all the experiences and tricks indispensable in the search for its food—the fruits.

The difficulties involved in obtaining food and the mental effort excited by play thus equally assisted in developing the intelligence of the fruit-eating animal; they favored further the imitative faculty, which especially causes the cleverness of these animals when imprisoned. In this way suitable actions could accidentally be transmitted from one individual to others, and were by them, perhaps consciously, developed and preserved.

And the detailed instruction of the young one carried by its mother and the various plays with comrades might require also an extended and lasting communication, much more than the warning cry before an enemy, or the calling for plenty of food, or the anxious calling of the mother, in which respects only animals usually need intercourse. And so the fruit-eating animals could develop a language (already noticed mechanically with ants) the richer, the more perfect as the shape of their mouth was developed.

As a striking mark of their special intelligence appears finally in all classes that care for the future which is shown by the accumulation and storage of food; as with bees and ants, and also with rodents, a practice which is possible again only by virtue of the peculiarities of their food, i. e., of the durability of the fruits.

Thus the intellectual development of the fruit-eating animals was influenced in a favorable way, and primeval man, the highest of them, was constantly improved in the same direction by his bodily advantages. The easy wandering on the ground which permitted him to search over a much more extended region for food, widened his horizon, allowed him to discover various fruits, and stimulated his faculty

of invention in obtaining them in ways that were impossible for the monkeys. Their horizon reached, on their oscillating dwelling place, where the foliage prevented a wide view, scarcely to the next tree; and when they climbed the highest top, it was again bounded by a green sea of foliage, offering there, in consequence of the narrow space and here on account of the immense dimensions, equally little mental stimulation.

But man could, like them, and much better, find out an isolated high tree, climb it, and look out for prey or enemy, replacing the senses of smell and sight of the beast of prey, and protecting himself better than by the hearing power or quickness of the herbivorous animals. He has likely originally always looked for this safe plan of refuge, defending himself, like the monkeys, much more easily in this place.

On the ground his helpless condition pressed soon into his hands the most natural and simple implement and at the same time weapon, by means of which he could well bend down a high branch with fruits, tear open the ground while looking for roots, defend himself or attack his enemies --the hooked stick, a forked branch with one long and one short arm, by its length and firmness the more suitable imitation of the stretched arm with the bent hand, the prototype of hoe and plow as well as lever and fishing hook. Since he could use this implement while standing upright with his two hands, he was, in spite of his bodily weakness, far better equipped for the search of food and his defense than any other animal before him.

And should not man have gradually acquired on a large scale what the tiny ant was perhaps doing long before him on a small scale—grow useful plants and improve them, as the ant grows mushrooms; foster domestic animals and milk them, as the ant does plant lice.

The human intelligence could continuously grow by the faculty of imitation, since every individual by new experiences, either his own or learned from his comrades, could increase the treasure inherited from previous generations; and it would grow the quicker, the more variegated the acquisition of food was and the way of living depending on it; the slower, the more the exertion of the body to get food outweighed the exercise of the faculty of mental combination. And thus this preponderance of mental work over physical for the purpose of getting food, which was the starting point and the fundamental condition of intellectual development in the individual, is still acting in the same direction to produce in the individual the climax of his education, and in the whole community of men united by reciprocity, in the nation, the climax of its culture.

EMPHASIS UPON ANTHROPOGEOGRAPHY IN SCHOOL

By ELLEN CHURCHILL SEMPLE, Louisville, Ky.

Every state or nation includes two ideas, the land and its people, each unthinkable without the other. Even the Sahara suggests, besides its wastes of sand, the group of huts in the palm-grown oasis, the white-robed Arab sitting in the shadow of his tent by a solitary well, the camel with his brown-skinned driver bending before the blast of the simoom, and the long-drawn caravan creeping along a bone-marked trail. Geography is the study of the land and its effect upon its people. History is the study of a people, in whose economic, social, and political development the land is an essential and potent factor. Geography lays the stress upon the land, history upon the people. But the land is fully comprehended only when studied in the light of its influence upon its inhabitants, and a people can never be understood apart from the field of their activities—the climate which determines their housing and dressing; the rainfall and soil which control their agriculture; the isolation or accessibility of their country, which defines the amount and character of their intercourse with other lands; and finally the size of their territory, which must always be a factor in the numerical strength of the population.

By the introduction of the human element, geography is lifted out of the dull round of formal studies in viewing man as the supreme product of the earth's surface.

By the introduction of the geographic element history becomes vitalized: through it now pulses the life blood of the people. All the forces and treasures and beauties of nature enter into the chronicle. Its pages seem to smell of the upturned soil; they are golden with fields of ripened grain and white with fields of cotton; they echo the sound of the pioneer's ax blazing a trail over a forested mountain pass, the ripple of the voyageur's canoe exploring some far northern stream, the splash of the steamboat on a river highway, the roar of waterfall and the whir of mill wheel, the lowing of cattle on thirsty plain, and the hum of life in the big seaport; they reflect the persistent, potent forces back of political bodies and legislative enactments in the geographic conditions of the people.

The chief emphasis in the two studies should not be changed, but this is still compatible with a fuller, deeper geographical interpretation of history than is now customary, and a more fruitful and varied anthropological interpretation of geography. Though the newer geographical text-books give an interesting and scientific treatment of earth forms, the sections devoted to the various countries of the world are burdened with masses of economic detail which in themselves are uninteresting to a child, which are imperfectly presented in their causal relation, and which are never stated in their bearing upon history, the next study in the school curriculum.

Economic facts appeal little to the child; their study is proper only for the mature mind, and hence their multiplication in geographical text-books is stultifying. Yet the causal idea back of a group of such facts the child will seize and retain. For instance, he is not eager to learn or sure to remember that Troy, N. Y., is an important center for the manufacture of collars and cuffs, Cohoes for knit goods and hosiery, Utica for fine hardware and machinery; but he can grasp the principle that all these are manufacturing towns, because their location on the great canal and valley railroad route between the Hudson River and the Great Lakes renders them accessible to raw materials of all kinds and enables them to send their finished goods to widely-distributed markets, while local water power reduces the item of fuel in the cost of production. In the same way the child can readily understand the geographic factors which have made England lead the world in manufactures and which have localized the great manufacturing area in the northwestern part of that country, but he gains little by memorizing a list of the chief industries distinguishing the various English cities. The teaching of geography would gain, therefore, both in interest and educative value by paying less attention to the mere enumeration of details and more to their scientific interpretation.

This multiplication of economic facts, which has so expanded the text in recent geographies, has crowded to the wall the important study of the map. Earth forms are slighted in their geographical distribution and their effects as phases of geographical environment. The old routine, illogical map questions have not been succeeded by intelligent, logical map questions designed to develop anthropogeographical principles. The drainage system of Russia, Germany, China, or America are described in the text, perhaps; but the child is not sent to the map by discreet questions to discover those drainage systems for himself and particularly to estimate their importance for their respective countries. And every child should become an infant discoverer on the cartographical page in order to acquire a self-constructed knowledge of every ocean, continent, and country as the basis for anthropogeographical deductions. Maps, physical and

political, must remain the child's chief repository of facts, to which he can most easily refer and from which he can draw his surest conclusions. Trained to this anthropological interpretation, he finds the otherwise dull page becoming luminous. The facts and principles thus acquired introduce him to contemporary history, the terms and names of which are more or less familiar to him, and by comparative methods into past history. Moreover, they deal with themes far more likely to interest him than the weary enumeration of economic data. A list of Cuba's mineral resources or a statement of its commercial exchanges with other countries does not appeal to a child, and is not readily associated with the Cuba which he knows best, the Cuba of the map; but if you would arouse his interest, point out the isolation due to Cuba's island character, show him that to this separation from the mainland and to the island's limited size was due in large part its long subjection to Spain, when all the other Spanish colonies in Mexico and Central and South America had gained their independence, either because the vast extent of their territories and their consequent larger populations rendered their uprising more formidable, or, as in South America, because continental neighbors, like Colombia and Venezuela, Argentina and Chile, sent armies even over the high barrier of the Andes to support each other in the struggle for freedom, while Cuba's seagirt location, accessible only to ships, which the new-born Latin Republics lacked, kept at arm's length the deliverer, and Cuba's relatively small area could be retained under the crushing hand of Spain. Finally Cuba's proximity to the United States and her strategic position on Florida Straits become obvious factors in her independence and the guaranty of that independence by the American Government.

In the same way lead the young student to read from the map the restricted availability of Russia's coast line; its White Sea harbors, accessible from the open ocean but closed by ice more than six months of the year; its Baltic coast, also hampered by a long winter, liable in time of war to be bottled up by Germany, Scandinavia, or the ships of England patrolling the narrow exit; its Black Sea coast, to which the neck of the bottle is particularly small and the cork secured for all naval vessels of the great Muscovite power; its far northern strip on the Pacific, with the often ice-bound port of Vladivostok, where, moreover, the long cordon of the Japanese islands makes the Japan Sea another Euxine and the Korean Strait another Bosphorus; the significance of the struggle for a maritime outlet on an unfrozen sea in Manchuria; and finally the meaning of the ominous bulge of Russia's frontier south of the Caucasus and the wedge driven into northern Afghanistan, signposts on her proposed road to the Persian Gulf and the Arabian Sea. Ask the child to estimate from the map the value of the coasts of all the European countries, in terms of length,

harbor facilities, availability, and routes of communication with the interior. See how eagerly, from an inspection of the coasts of Germany, France, Russia, and the United States, as interrupted by the intervening littoral of a foreign power, the child will reason to the political necessity of a canal to connect the separated coasts, and from a study of a physical map will fix its possible location. Tell the child that the Samoyedes, a retarded people of arctic Siberia, have 21 different words for the color gray, and ask for the geographical reason of this surprising richness in a primitive language.

The map, thus treated, becomes for the young student a great field for comparison, and hence for the deduction of anthropogeographical principles. Tracing the strategic and hence political importance of the entrances to inclosed sea basins, he reads at a glance the significance of Habana and Key West for the command of the Gulf of Mexico, of Constantinople for the Black Sea, of the Russian fortress at Port Arthur for Pechili Gulf, of the British positions at Singapore, Aden, Suez, and Gibraltar; he groups with these strategic points Denmark's peninsula and island location on the channels leading into the Baltic, and readily grasps the fact that this location made the historic greatness of the country in the past, enabling it to levy toll on merchant vessels entering this northern Mediterranean, and has prevented its absorption by one of its larger neighbors, because all these could agree to leave this important passageway in the hands of a weak and neutral power.

To recapitulate, this interpretation of the map has the following advantages: Its method is comparative, and hence scientific; it arrives at anthropogeographical principles interesting and comprehensible to an immature mind; it deals with familiar present day history, and leads from the present to the past; finally, it is a natural preparation for the study of history, which immediately follows geography in the school curriculum. The American child goes from the study of geography to the history of the United States. He possesses a valuable stock of facts about the climate, location, size, coast line, and topography of his country, ready to serve as the basis for his study of its history, but rarely or inadequately utilized for this purpose by school text-books. The valuable ready-made foundation is ignored, the child begins immediately on the superstructure, and his history hovers in the air.

The geographical element in history as taught to-day in the schools, taught often, too, in compliance with college requirements, is for the most part superficial and inadequate. It consists chiefly in memorizing geographical locations by very imperfect map drawing, yielding to the student scant profit in proportion to the expenditure of time and effort, or in filling in outline maps, guiltless of any suggestion of topography, with political boundaries and sites of towns and battles. The study

is not in the least interpretative; it makes no demand upon the reasoning power. The teacher asks the student to locate the battles of Oriskany, Ticonderoga, and Saratoga in the Revolution, and is satisfied with the answer that they were in the central part of eastern New York, overlooking the important fact of their location along the two great valley routes, between flanking mountain barriers, from Lake Ontario on the west and the St. Lawrence on the north, converging upon the upper Hudson, that great river highway through the heart of the colonies. In the war of 1812 the land battle of Saranac River and the naval engagement offshore are located by the student near the northern end of Lake Champlain, but are not shown to be a repetition of the battles of Ticonderoga and Valcour Island in the Revolution, pushed a little farther north on this same great Champlain-Hudson route; or the numerous naval conflicts in this later war are located vaguely in the wide waste of the Atlantic, with no regard to the great trade routes, determined by prevailing winds and ocean currents, which were followed in that day by English merchantmen seeking the West or East Indies, and which therefore were infested by American vessels preying upon English commerce. I remember distinctly, when a child 10 years old, studying the list of naval engagements in this war, with the names of vessels and commanders on either side, and wondering, in my childish mind, where all these battles were, and why they were anywhere. If I learned that the conflict between the *Constitution* and *Guerrière* took place southeast of Sable Isle in such longitude and latitude, I was not much wiser, because the significant fact in this location was carefully suppressed—namely, that this battle was fought near the southern entrance to the Gulf of St. Lawrence, where American vessels throughout the war were lurking about to intercept English supply ships on their way either to the St. Lawrence River and the forces in Canada or to the British naval base at Halifax.

The geographic factors in the history of Greece receive more attention in school text-books than those of any other country, but here only the more obvious influences are discussed—the political subdivision of the country due to physical subdivision by mountain barriers and arms of the sea; the indented coast line, the fringing island groups, and the proximity of other lands resulting in the seafaring and colonizing propensities of the early Greeks; the effect of climate, quality of atmosphere, and scenery upon the artistic development of the Greek mind—while other equally important influences are passed unnoticed. The marked colonizing tendency of the people was a result also of the restricted territory of the little peninsula and the limited amount of arable soil in a land of rugged mountains and sterile plateaus. In a country where to-day only 18 per cent of the surface is under cultivation, population must at an early date have begun to press upon the limits of the subsistence yielded by primitive agriculture. Emigration

from congested districts necessarily followed, and foreign commerce was resorted to in order to increase the earning power of the states.

But, as Ratzel says, "The most important fact in the history of Greece was its location at the threshold of the Orient," and yet this factor is never brought out in its full significance. Greece was the part of Europe most accessible to the ancient centers of civilization in Egypt and southern Asia; upon it converged all the great routes from the East, which poured into the Hellenic world the intellectual and commercial wealth of the Orient. The Mediterranean and Black Sea termini of all such routes were marked by Greek colonies—Trebizond, Sinope, Byzantium, Smyrna, Miletus, Antioch, and Naucratis in the Nile delta. Over the eastern rim of the Ægean rose the sun of Greek culture, flooding with light the islands of that sea, the Asia-fronting shore of the peninsula, and the eastern slopes of the Pindus Mountains, while a gray uncertain dawn long defined the westward-reaching shadow of the massive range. Then by its position midway between the productive countries of the East and the newly opened lands of the western Mediterranean Greece became the great middleman of the early world, the distributing center of products and ideas, just as twenty centuries later the Hanse towns of the North Sea and the neighboring Baltic became the agents of Mediterranean commerce and culture for the less-developed coast regions of northern Europe.

When the maturer student has acquired a knowledge of general history and passes to the advanced study of physiography he commands the material for broader anthropogeographical conclusions, which in turn give him a larger outlook upon history. The study of the physical features of fiord coasts and countries will gain immensely in interest if followed by a comparison of the influence of fiord environment upon the Indians of southern Alaska, the people of Iceland, Greenland, and Norway, as also its effect upon the economic development of British Columbia, Washington, and Maine. A study of continental islands is complete only with a comparison of the isolating influence of an island environment in Japan, England, Iceland, Corsica, Madagascar, Cape Breton, and Cuba, and with an analysis of the striking and not fortuitous parallels in the history of England and Japan. The study of mountains should culminate in an investigation of their isolating effects in the survival of moribund languages in the Alps, Pyrenees, Caucasus, the Highlands of Scotland, the mountain districts of Wales and Ireland, and the persistence of a seventeenth-century English in the remoter parts of the southern Appalachians to-day. All mountain peoples are found to have certain characteristics in common, especially a love of political and personal freedom, which explains the existence of small, independent mountain states like Switzerland, Andorra, Montenegro, Nepal, and Bhutan; the fierce and protracted resistance to conquest made by the ancient Samnite tribes of the

Apennines, the Highland clans of Scotland, the tribes of the Caucasus and Himalayas, and the Albanian mountaineers of Turkey; and it accounts for the habitual disregard of governmental authority displayed to-day by the people of the isolated southern Appalachians in matters of clan feuds and illicit distilling.

By comparison of different periods, also, the same geographic factor is seen to operate continuously, though under new aspects, caused by a change of other conditions. For instance, certain mountain passes and the river valleys leading from them down either slope have determined the routes across the Appalachians, whether of "buffalo traces," or Indian warpath, or the well-beaten trail of the pioneer, or the wagon road of the early western emigrant, or the line of the railway seeking the easiest path across the wide-stretched barrier. In the same way that deep furrow between the mighty Caucasus and anti-Caucasus Mountains, which served as the ancient route of communication between the Black Sea and the Caspian, and brought the gold of the East to mythical Colchis, sees to-day the railroad which brings the petroleum of Baku and the rugs of Bokhara to the Mediterranean lands. The geographic conditions which made a maritime power of ancient Greece still enable the modern country to lead in the carrying trade of the eastern Mediterranean. The arid plains and mountain slopes of the American West, once the grazing lands of the buffalo and deer whose skins figured prominently in the early exchanges of the busy little towns at the elbow and mouth of the Missouri River, to-day raise the cattle and sheep to supply the great slaughtering and packing industries at St. Louis and Kansas City.

These geographic forces are stable, persistent; they operate from day to day and from century to century. They constitute the soil in which empires are rooted, and they rise in the sap of the nation.

CLIMATE AND CULT

By J. WALTER FEWKES, Bureau of American Ethnology

The science of anthropogeography, or, more properly speaking, psychogeography, deals with the influence of geographical environment on the human mind. The effect appears in that responsive expression of mind which is known as culture. Evolution of culture is the resultant progress of man as influenced on the one hand by advantages of external nature and on the other by efforts of the mind to overcome its disadvantages. In this struggle of mind to control its environment the latter predominated in early stages of culture evolution, when the mind was weak and in a measure plastic. Here the influences of geographical conditions were more evident, affording the anthropogeographer suggestive material for study.

Climate is one of the most potent geographical causes which affect mental development. I present for your consideration a brief discussion of its influence on cults. Climatology embraces the study of laws of heat and moisture which affect organic life, but these laws can be traced to higher causes. The amount of heat or of moisture in any one locality on the earth's surface is due to the geographical configuration of land masses, latitude, trend and position of mountains, and other causes, so that we can logically affirm that the culture of man as affected by climate is, properly speaking, influenced by those causes which produce climate, viz. the geographical features of the earth.

The necessity for food affects the human mind with a force unequaled by any other, for the food quest is a stimulus to thought in comparison with which all others shrink into insignificance. Man's supply of food, in whatever stage of culture, depends on plant life. There is no game for a hunter without plant food for animals. Pastoral life was evolved from grazing; agriculture from the discovery of food plants. All human food supply depends on the plant, and heat and moisture are the primary causes which determine the distribution of plant life on the earth's surface.

Thus our chain of causes from geographical conditions to culture is complete. The mind of man is stimulated and directed by a food

quest. The supply of food is determined by the character of plant life, which is directly dependent on climate, the result itself of geographical conditions, or, skipping intermediate links in our chain, we find that the element in culture due to environment is an expression of purely geographical conditions.

In considering this aspect of my thesis I recognize that the food supply of certain primitive human communities is wholly independent of terrestrial climate so far as plant life is concerned. The abundance or scarcity of sea animals has the most vital relation to the food supply of certain coast tribes. Climate would seem to have affected their life and culture comparatively little in the way above suggested. History shows that the first steps in culture were never taken by coast peoples where the ocean yielded a natural food supply.

Carl Ritter, the founder of the science of anthropogeography, long ago pointed out the relationship of organic life to the character of coast lines. He taught that the flora and fauna of each continent stands in direct correlation to the simplicity or complexity of the coast line. He showed that Australia, America, and Asia-Europe stand in an ascending series in the character of their organic life; that this relationship is connected with the physical features of those continents. Man's culture, which is directly dependent on the same conditions, follows a similar law in its distribution. Uniform coast lines are indicative of simplicity in geographical conditions resulting from an absence of repeated changes in land configuration, while complex contours indicate repeated geological changes of elevation and depression. In those regions of the globe where lands are either rising or falling, or where geological changes follow one another more or less rapidly, coast lines are necessarily complex. Here the responsive mind of man is continually adjusting itself to new relations and thereby is stimulated to greater endeavor, the inevitable result of which is an advance in culture.

The fact that man reached a higher cultural development in Asia-Europe than in America does not prove in itself a longer existence of the human race on the former continent. The most advanced race is not necessarily the oldest, for the degree of culture depends not on age, but on rapidity of development. Man may have existed as long in the so-called New World as in the Old, but changes of geographical conditions have been less frequent in the former than in the latter and culture stimuli less powerful. The lineage of the savage is as ancient as that of the civilized man.

In a remarkable course of Lowell Institute lectures, in which he expounds the work of his great master, Guyot has pointed out that America is essentially the oceanic hemisphere or vegetable world, what he aptly designates "the humid side of our planet." "The climate of the New World, compared with that of the Old, is distinguished by

the abundance of pluvial waters—in general, by a greater humidity," a condition directly traceable to the comparative simplicity of the continental contour and geographical position of the great land masses.

The effect of this prevalence of rain, and consequent exuberance of vegetation, on the mind of prehistoric man in America is clearly evident. His development was retarded, or rather climatic conditions compelled him to remain in a lower or more primitive mental condition. The natural food supply is more abundant in a humid than in a desiccated continent and incentive to increase the food supply by artificial means is less pressing. Thus, he concludes, tropical man in prehistoric America reflects the climatic conditions of a humid vegetable world peculiar to the American continent.

Although, as a whole, America, especially that part of it best adapted for human life, is essentially humid and prolific of vegetation as compared with the old continent, this condition is not universal. There are portions of America the climate of which resembles that of the Old World, where culture first developed. A great belt of dry desert land, interrupted at intervals by well-watered sections, extends from the southwestern part of the United States through Mexico to Peru and southward to Patagonia. This zone is, as a rule, mountainous, but in the lower latitudes has lateral extensions to the coast. As compared with the arid regions of Africa and Asia the American area is small, its longitudinal extension being at right angles to that of the other continent. It extends from one temperate zone to the other, but its climatic conditions have in certain parts some likeness to those of the vast belt of deserts which stretches across Africa through Arabia to the center of Asia. In this zone, which in climatic conditions is totally different from the humid vegetable world which, as the early anthropogeographers pointed out, characterizes America in general, there developed in prehistoric times the highest form of American culture.

Among the main causes which have led to advance in culture, Payne has given due weight to the substitution of an artificial for a natural food supply. Certain regions of the globe are particularly favored by climate for the operation of this law. It is practically inoperative among peoples blessed with abundant natural food or those who rely upon a perishable food supply. Tropical forests with an exuberant vegetation and resultant animal life discourage the inventive impulse, and abundant game makes it unnecessary among hunters. It is a matter of more than passing interest that the earliest efforts of man to substitute an artificial for a natural food supply originated where natural food is not abundant, and man has had to increase it artificially to meet his needs. Climate, in determining the distribution of the fauna and flora of a given locality, dictated to man whether he should advance in cultural development through a pastoral or agricul-

tural stage. Development in the former necessitates some ruminant susceptible of domestication which could be made to yield him food and raiment. The mountains of South America had in their native fauna an animal of this kind—the llama. It is highly probable that the Peruvian culture was largely due to the existence of this animal. The geographical laws which limited its distribution and prevented its transportation into the humid lowlands set lines of demarcation in the distribution of the civilization which it created. Pastoral stages of culture could never arise in the midst of an exuberant vegetation of the Tropics with its teeming animal life. There are too many enemies of the shepherd and his flocks in these localities. The inducements to cultural advance through an agricultural stage were greatest in America where they might least be expected. The fertile, well-watered valley of the Mississippi was suited for farming, but had this disadvantage, that the presence of migratory ruminants rendered agriculture hazardous on account of savage hunters who followed them. As long as the bison was abundant there was no inducement to become agriculturists.

In the arid zone, where the natural food was scantier, the cultivator was less exposed to attacks of enemies. Although the land was less fertile, the agriculturist was more sheltered in these regions from wandering marauders. Here agriculture naturally developed and flourished.

Aridity in climate tends to develop an agricultural life; humidity fosters the hunter stage. The reason for this is obvious: An abundant rainfall is accompanied by a luxuriant plant life, which renders animal life abundant. With abundant animal life man finds a ready natural food supply in animal food, and feels no inducements to agriculture. Although a well-watered plain is more propitious in itself to agriculture, and although it would seem that agriculture would first develop in so favored a region, the abundance of game, due to abundant plant life, keeps man in the hunter stage. A humid continent is the natural home of hunters.

In arid regions game is limited, and man is forced to rely on such scanty crops as he can raise for his food supply. In an endless conflict between the hunter and the agriculturist, climate gives the advantage to the former in humid regions abundantly supplied with game, but favors the agriculturist in the arid regions of the earth.

The mind of man when affected by a desert environment early recognized the dependence of his crop on climatic conditions—on heat and moisture. He was continually haunted by the thought that rain might not fall, that heat might be withdrawn, and the seed might not germinate and grow. To avert these misfortunes he thought out to his own satisfaction a means of preventing these disasters. He slowly accumulated through experience a system by which adverse

circumstances could be met and rational agriculture developed. But with this system there grew up another, of empirical nature, which he also regarded as useful. False theories of what caused rain, heat, and the power of germination arose and magnified themselves in his mind. One of these theories was that atmospheric and germinal processes were due to magic and could be controlled by sorcery, and another (born from a confusion of the real with the ideal) was that effects were causes, and that resemblances in objects meant possession of equal powers. In this rank growth of error environment found a fertile soil for its influence, and empirical methods of agriculture held sway over rational methods; heredity perpetuated these figments of the fancy and crystallized them into a system of cults.

This phenomenon is well illustrated among the aboriginal cultivators of our Southwest, known as the pueblos. The most important ceremonies of the Hopi Indians of northeastern Arizona are practically very elaborate prayers for rain and for the germination and growth of their natural food—corn, beans, melons, and other products of their farms. In these prayers the supernatural powers addressed are represented by men, masked or painted, or by idols, pictures, or other symbols. In order to influence the magic power of these personages the worshiper employs signs or gestures, songs or verbal prayers, through which he exerts his magic power. In the gesture prayers imitations of what is needed are common. Water, for instance, is poured into a medicine bowl from its four sides to show the gods that rain is desired from all world quarters; the worshiper asperges to the different directions to indicate the same request. Smoking to cardinal points is a sign prayer, and has the same signification, for a cloud of smoke represents symbolically a rain cloud, and the worshiper wishes rain, which comes from a cloud.

Innumerable instances of supposed communication with the gods in such ways might be mentioned. All the altars that are erected in the sacred rooms or kivas bear paintings of rain clouds, from which falling rain is shown to remind the gods of the ever-present prayers of the farmer. Lightning, which is accompanied by rain, is also represented for the same reason. The inevitable response to all inquiry as to the meaning of Hopi cults is that they were inherited from the ancients, and that they practice their ceremonies because they are efficacious to bring rain.

The arid climate of our Southwest is so strongly stamped on their ritual that every student will recognize its influence in creating and perpetuating the elaborate ceremonies which they practice. When we examine the antiquities found in the ruins of the same region we find abundant evidence of an ancient connection between climate and cult. The ever present rain-cloud symbol affirms the fact that the ancestors of the pueblos had the same rain ritual; that they likewise

were dependent on climate for their food. This ritual has resulted from centuries of this influence and has practically become crystallized, resulting in an elaborate system which has survived to the present day.

An analysis of this ritual shows that it is built on the worship of a sky god, an earth goddess, and innumerable ancestors who have been exalted into lesser gods. This mythological background of ceremonies arose from inherent ideas which the early pueblos share with other primitive peoples. The details of worship of their gods and the special powers ascribed to them have been modified by the arid climate in which they originated.

We can hardly imagine two regions of the Western Hemisphere where climatic conditions are more radically different than the arid pueblo region and the well-watered Antilles, Haiti, and Porto Rico. It is instructive to see how climate in these diametrically opposite moods had affected the cults of prehistoric man dwelling in these two localities.

The aborigines of the West Indies, like those of the pueblo region, worshiped a sky god, an earth goddess, and innumerable deified ancestors which were called Zemis. They also were practically agriculturists, for their food (outside of a few animals) was mainly vegetable. Their ancestors devised a method of so treating the yucca root (*Vatropha manihot*) by extracting its poisonous juice as to make it into cassava, a food supply. The rains necessary to supply sufficient water for the West Indian farmer rarely failed, but hurricanes, with accompanying floods, often devastated his fields. Except in the central part of Haiti, where prehistoric irrigation is said to have been sometimes employed, the certainty of the rainfall was fixed and drought was never feared. There was in these islands not too little but at times too much water for successful agriculture. This climatic condition exerted a profound influence on the cults of these islanders. They had no elaborate system of ceremonials to bring rain, although their main ceremonial was devoted to the earth goddess to cause their food plants to germinate and grow. They observed elaborate rites over the dead, but never regarded their ancestors as rain gods, as is the case with the pueblos. They worshiped the sky god, but not for sending water or aiding them in the germination of their crops. Their sky god was a personation of the destroyer of their farms by torrents of water; consequently they regarded him as a malevolent being, to whom prayers were made for protection from tornadoes. This god, under the symbol of a great snake, Mabouya or Hurakan, the tempest, was the dominant supernatural being in their pantheon.

These examples, showing the divergent influence of climate on the cults of two widely separated aboriginal peoples of America, might be increased to hundreds, but the increase is not needed to establish the

thesis. Whatever may be the difficulties or the capricious climatic phenomena that beset the prehistoric agriculturist, his cult is correspondingly modified. If rain be scanty, his ceremonies are mainly directed to increase the supply; if too abundant, the fear of disaster profoundly modifies his ritual. Cult being directly dependent on climate, as the instances cited show, resemblances in symbols that express religious ideas may be traced to climatic similarities in different regions of those zones. The mind being homogeneous, when the environment by which it is affected is the same the resultant cultures must necessarily be identical. Climate is thus in large measure responsible for both likenesses and diversities in cults, similarities in one leading to likenesses in the other. This is an important anthropogeographical law, a failure to recognize which has led to many errors in the interpretations of cultural identities and diversities. Identity in the working of the human mind is recognized by all anthropologists, and the tendency to ascribe cultural identities, as shown by the same symbols in widely separated regions, to contact or migration is much less prevalent now than formerly. Similarities of climate may be regarded as an adequate explanation of many resemblances in cults. From this cause, rather than from contact, have arisen like cults and symbols in the arid regions of both continents.

THE PEOPLES OF THE PHILIPPINES

By HENRY GANNETT, U. S. Geological Survey

The people of the Philippine Islands present the widest possible variation in culture, ranging from the cultivated gentleman educated in the universities of Europe down to the wildest of head-hunters and tree dwellers. There are about 7,000,000 so-called civilized people, all of whom are Christians and Catholics, excepting about 40,000 Chinese and 11,000 whites.

We commonly hear this people spoken of as divided into tribes, but in the ordinary acceptation of the word there is no such thing as a tribe in the Philippine Islands; there is absolutely no tribal organization either among the civilized or wild people. There is, it is true, a certain clannishness among the people of a so-called tribe, due mainly to the fact that they speak a more or less common tongue. Among the wild people, those of each village are united under its head man, and, at least in certain tribes, are at odds with all the neighboring villages. Thus the only unit of organization among them is the village. This statement may be qualified to some extent in the case of the Moros—the Mohammedan Malays. Thus the sultan of Jolo claims a wide jurisdiction, including the Sulu Archipelago and northern Borneo, but as a matter of fact his authority is by no means unquestioned, even in the little island of Jolo, and beyond its shores he has absolutely no authority. Certain datos have by virtue of their ability extended their jurisdiction over small areas; several villages may thus be obedient to the authority of a single dato, but this is an exception; as a rule the Moro villages, as well as those of the other peoples, are independent of one another.

The census of the Philippine Islands recently taken made an attempt to obtain the total number of the wild people, with distinction of sex and age—that is, whether children or adults—in addition to the work of enumerating, with fullness of detail, the civilized people. In view of the confusion that exists concerning the number of peoples or tribes found in the islands, the census secured the assistance of Dr. David P.

Barrows, then the director of the bureau of ethnology of the islands, in the hope that through his aid a satisfactory classification of these peoples might be obtained for the use of the census. The results of this work I shall place before you.

Taking up first the question of the civilized peoples, there have been universally recognized the Tagalogs of central Luzon, the Pampangans and the Pangasinans of the central valley of Luzon, the Ilocanos of northwest Luzon, and the Cagayans of northeast Luzon, in the valley of the Cagayan River, the Bicols of southern Luzon, and the Visayans of the southern islands. The question whether there is a Zambalan people inhabiting a large part of the province of Zambales was decided in the affirmative.

In the Visayan Islands there is found a rather curious situation. Although the people of those islands are generally supposed to speak the same language, those of Cebu can not understand the Visayans of adjacent islands. Moreover, in the Cuyos and in the Calamianes islands, dialects are spoken which differ in some respects from the Visayan, but on the whole it has been deemed best to class these with the Visayans, thus making eight civilized peoples. The locations of these peoples are shown by the solid colors on the accompanying map, where they have been platted with care from the census returns.

The civilized peoples are distributed among the various tribes in approximately the following proportions: Visayans constitute 47 per cent, or nearly one-half; Tagalogs 21 per cent, or a little more than one-fifth; Ilocanos 12 per cent, or about one-eighth; Bicols 8 per cent, or about one-twelfth; Pangasinans 5 per cent; Pampangans 4 per cent; Cagayans 2 per cent, and the Zambalan less than 1 per cent.

With the wild peoples the problem was much more difficult. Of these the Jesuits recognize 79 tribes and Blumentritt even a larger number. It is the belief of Doctor Barrows—and in that I am in hearty accord with him—that the distinctions and differences among these peoples are not sufficient to warrant a separation into anything like so large a number of different tribes. The net result of Doctor Barrows's studies is to consolidate them into 16 peoples, and in all probability the number will be still further reduced as investigation progresses among the peoples of the interior of Mindanao.

The Jesuit fathers and Blumentritt agree in regarding certain peoples of southeastern Mindanao as of Indonesian origin. With this Doctor Barrows does not agree, and I find myself again in accord with him. The great stature, aquiline features, and light color assigned to these people do not belong to them. They are as clearly Malay as other peoples of the archipelago. With the exception of the aboriginal Negritos, the Chinese, and other immigrants, all the Filipinos are Malays.

The Negritos number about 23,000, and under various names, such as Atta, Eta, Aeta, and Mananua, are widely distributed over the archipelago, but always back from the coast among the mountains and in the forest. Their blood is now generally mixed with Malay blood, so that pure Negritos are not common. They are the aboriginal inhabitants, who have been driven into the interior by successive invasions of Malays.

In northern Luzon most of the wild people are included under the name of Igorrote. To this people have been assigned all the wild Malays in the country north of Laguna de Bay and Manila, excepting one people inhabiting the country about the headwaters of the Cagayan River, which are separated under the name of Ilongot. The Igorrotes inhabit an elevated mountainous region having a climate decidedly cooler than the lowlands, and this has resulted in giving them a physique decidedly superior to that of the civilized peoples and much more industrious habits. In the main they are a well-disposed, happy, jolly, hard-working lot. They differ in culture in different regions, those living in the subprovince of Bontoc being still wild to the extent of taking heads from their neighbors and living on a pretty low plane, while those in western Lepanto and in Benguet have made considerable progress, wearing clothes sometimes, and living in a much more civilized way. Some of their children attend schools and many have been baptized. There are about 200,000 Igorrotes.

The people of the interior of the island of Mindoro are all classed as Mangyans, although other names have been given to many of them by different travelers. They are probably of mixed Malay and Negrito blood. The wild people of Paragua, aside from a few Moros who inhabit the southern part of the island, are thrown into two groups, the Tagbanua and the Batak. The former comprise most of the wild people inhabiting most of the interior of the island, while the latter are found only at the northern end, in the neighborhood of the town of Taytay.

In the interior of several islands are found wild people identical with their civilized neighbors, who differ from them only in the fact that they have never been Christianized, but have remained in a wild condition. These are collectively called Bukidnon, and nearly all of them are found in the Visayan Islands.

We now come to the wild people of Mindanao, about whom the least is known, and for whom there has developed the greatest multiplicity of tribal names.

The most numerous of all the wild people are those whom collectively we call Moros, meaning of course Mohammedanized Malays. These occupy the whole of the Sulu Archipelago, the coast of southern Mindanao, the valleys of the Rio Grande del Mindanao or the Cota-

bato River, the country surrounding Lake Lanao, and the northern coast in the neighborhood of Iligan. They also occupy the coast of southern Paragua and the adjacent islands, and altogether number about 275,000. These form by no means a homogeneous people. They have migrated from the south, coming at various times. Their state of culture differs widely, ranging from that of settled people engaged in farming and having some knowledge of mechanical arts, with ability to read and write (of course in Arabic), down to that of the sea gypsy or Bajao, whose home is in his boat from the cradle to the grave and who knows no art but that of fishing. Barrows groups the Moros partly by locality, partly by culture stage, as follows: Maguindanao Moros in Cotobato Valley, Malanao Moros about Lake Lanao, Ilanao Moros of the southwest coast of Mindanao, Jolo Moros of the Sulu Archipelago, Samal Laut, and the Bajaos.

The wild, timid people of the interior of Zamboanga, and indeed of all the southwestern part of Mindanao, including a part of Misamis Province, are known as Subanos. They are oppressed by the Moros, who occupy the coast and who force them to pay tribute and exact labor from them.

Whether the wild people of eastern Misamis are Bukidnon, those Visayans who have escaped conversion to Christianity and civilization, or whether they are more closely akin to the Manobos, who occupy the country to the east and southeast of their range, has not yet been definitely ascertained. The latter is probably the case, but in default of definite information I have placed these few thousand wild people with the Bukidnon.

The Manobos occupy a large territory, comprising all of Surigao Province and a large part of Davao and Cotabato districts. They number about 21,000 and are sparsely scattered over this great territory. Landor recently found villages of Manabos who were nearly white; they had, though, characteristic Malay features. As suggested by him, the bleaching is probably the result of living in the dense forests, in which are their homes. The Bagobos are found on the shores of the Gulf of Davao to the number of 12,000. This is one of the peoples to which has been attributed an Indonesian origin. Nearly one-third of their number have been baptized in recent years through the labors of the Jesuit fathers. Adjacent to their territory is a small area on the slopes of Mount Apo that is inhabited by a people known as Atas, which also has béen regarded as of Indonesian origin. The peninsula of San Augustin, on the west or opposite shore of Davao, is occupied by a people known as Tagacaolo. This is a third of the supposed Indonesian peoples. In the mountains southwest of the valley of the Cotabato River are a people known as the Tiruray, numbering about 4,000. Finally, occupying an area around the headwaters of the

Gulf of Davao and the entire breadth of the peninsula over to the Pacific are the Mandayas, numbering over 20,000, two-thirds of whom are living in a wild state, the other third having been baptized and grouped into towns by the labors of the Jesuit fathers. Many of these people of Mandayan blood who have become civilized have returned themselves to the census not as Mandayas but as Visayans, regarding it as rather a disgrace to be identified with the Mandayas.

Of the wild peoples, the Moros, comprising all the Mohammedan peoples, are 41 per cent, or a little more than two-fifths of the whole number, Igorrotes 31 per cent, or nearly one-third, Bukidnon 8 per cent, the Subanos, Mandayas, and Negritos are each about 4 per cent, the Manobos about 3 per cent, and all other tribes together 5 per cent.

APPLICATION DES LIGNES D'ÉQUIDISTANCE À L'ÉTUDE ANTHROPOGÉOGRAPHIQUE DE LA MÉDITERRANÉE

Par PAUL VIDAL DE LA BLACHE, Paris, France

Je me propose de soumettre au congrès quelques observations de méthode, à propos de recherches que j'ai entreprises sur la population des bords de la Méditerranée; je voudrais montrer quel parti on peut tirer, pour cet objet, des lignes d'équidistance. L'emploi de ce procédé soumet les faits à une sorte de classification, qui facilite leur analyse. Si l'on a soin de mettre ces lignes d'équidistance en rapport avec les conditions physiques qui leur correspondent, elles permettent de mieux dégager les causes.

1°. *Zone de 0–5 kilomètres.*—Comme la Méditerranée n'a pas de marées pénétrant dans les fleuves, une ligne bordant le rivage à 5 kilomètres vers l'intérieur suffit pour envelopper les ports. Toutes les grandes villes de plus de 100,000 habitants sont comprises dans cette zone; Rome seule, parmi elles, se trouve un peu plus éloignée. Cette zone comprend également les rangées populeuses qui occupent les côtes appelées Rivière en Ligurie et en Catalogne, et qui sont un des traits caractéristiques de la démographie Méditerranéenne.

2°. *—0–20 kilomètres (de la côte vers l'extérieur).*—L'étude du littoral exige qu'on tienne compte des îles qui en sont assez rapprochées pour que des rapports familiers, fondés par exemple sur les brises alternantes de jour et de nuit, puissent s'échanger de part et d'autre. Une ligne d'équidistance extérieure de 20 kilomètres résume ces relations.

3°. *+5–20 kilomètres (de la bordure littorale vers l'intérieur).*—Une zone de 5–20 kilomètres embrasse la plupart des phénomènes littoraux qui exercent de l'influence sur la population; lagunes, étangs, sebkhas, etc. La densité de la population y montre de grands contrastes, résultant de la salinité, de la sécheresse, ou de l'irrigation. Des *huertas* populeuses y côtoient des plateaux *karstiques* déserts.

4°. *+20–40 kilomètres.*—La zone d'arrière-pays comprise entre 20 et 40 kilomètres abonde en phénomènes physiques intéressant la population. C'est là qu'en général se multiplient les niveaux de fortes sources; que les rivières changent brusquement leurs pentes; qu'elles

livrent leurs eaux à l'irrigation; qu'elles luttent pour leur écoulement vers la mer. Les parties marécageuses et salines des deltas fluviaux se prolongent jusqu' au delà de 30 kilomètres.[a] Les vents humides et gras, venus de la mer, ne gardent leur humidité que dans cette zone; plus loin ils deviennent desséchants.

5°. *+40-100 kilomètres et au delà.*—Entre 40 et 100 kilomètres se meut une circulation dont le littoral est la base. Les voies terrestres qui unissent les différents ports, s'écartent souvent à plus de 40 kilomètres du littoral. Les plaines littorales sont le point de départ de déplacements périodiques vers les montagnes. La transhumance gravite dans un rayon qui dépasse quelquefois 100 kilomètres. L'attraction des grandes villes, surtout dans le sud de la Méditerranée, agit à des distances considérables: les gens du Mzaf affluent à Alger, ceux du Nefzaoua à Tunis, ceux de Nubie à Alexandrie.

Les considérations altimétriques ne seraient pas moins dignes d'attention que celles d'équidistance; mais ce serait un nouveau sujet. On peut voir, d'après ce qui précède, quelle part revient aux conditions physiographiques dans la répartition de la population autour de la Méditerranée.

[a] Bararis dans le delta du Nil; Sansouires dans celui du Rhône.

THE DEMOGRAPHIC INVESTIGATION OF COUNTRIES WITHOUT CENSUSES

By Prof. CARROLL D. WRIGHT, Worcester, Mass.

The International Institute of Statistics at its last session, held in Berlin, resolved to collaborate with the International Geographic Congress in the demographic investigation of countries without censuses. The opportunity for such collaboration or consideration presented itself in the project for the Eighth International Geographic Congress, now in session, as this congress has invited the members of geographical societies or of similar institutions to take part in its deliberations and to offer propositions for discussion.

I have been delegated by the president of the International Institute of Statistics, in accordance with the Berlin resolution, to bring before this Eighth International Geographic Congress the question of a general movement to secure censuses in countries that do not now provide for enumeration. This question has been the subject of discussion by the International Institute of Statistics for many years, and the opinions of statisticians have been obtained, and, as a rule, they have been favorable to the proposition submitted.

To this end the bureau of the institute has caused to be drawn up certain schedules, chiefly the work of M. Rubin. These schedules, which have been approved by the bureau, have been sent to the different learned societies, not only those that are represented in this congress, but others. These schedules I submit herewith, and in connection with them two papers—first, the proposal made in connection with the universal census at the session of the International Institute of Statistics at Christiania in 1899, entitled "Projet d'explorations démographiques," etc.; the second, some official information recently collected concerning the last census in China. It is especially appropriate that these matters be brought before this congress of geographers, because it is especially important that whatever collaboration is undertaken in such demographic investigation should be between statisticians and geographers. This is the opinion of the president and members of the institute I have the honor to represent.

As incident to the value of the proposition which I submit on behalf of my colleagues the situation in China may be cited, where, notwith-

standing the official results of the last census in that country, showing a little over 407 million population, German authorities who have carefully studied the matter insist that about 320 million is the most probable number of the inhabitants in the nineteen provinces of China proper. It is, of course, very difficult to obtain full information about these matters, but it may be assumed that small nations will be more willing to give representatives the facts desired than would a nation like China. It may be that the answers which have been given by the Chinese authorities can not yet be considered as complete or satisfactory, but it is hoped that our knowledge about the Chinese census may be increased by the action of this congress. The chief point in this case as to the progress of the population statistics of China relates to the Chinese Government itself and the probability of that Government recognizing the utility of a more complete enumeration. Of course, it may be that even if this usefulness be recognized, the Chinese authorities may still keep their information to themselves, but it can not be doubted that when reliable statistics are provided by the Chinese Government such statistics will sooner or later enter into the common dominion of human science. Should there be any Chinese geographers present, I trust the subject of the general population statistics of that country may be discussed, and an opportunity offered for interesting them in a more complete census.

China is cited not in the way of criticism, but as offering a strong argument in support of the proposition made by the Statistical Institute. That institute has adopted a fairly complete scheme for such investigations as are contemplated, and has recommended it to about 150 geographical and other learned societies. This scheme has been carefully prepared by statisticians, but it ought to be submitted to the study of geographers in order that the plan, when eventually modified and perfected, can be approved by the geographers as well as the statisticians of the world. It would then come with a recommendation of double authority.

Therefore, in the opinion of the International Statistical Institute, and in my own opinion as representing that body, there should be a committee of geographers appointed by this congress to study the question submitted and to make propositions. Should such a plan be adopted whereby a special committee of geographers could act with a special committee of statisticians to be appointed by the Statistical Institute, then there would be made provision for the publication of the perfected plan in different languages in all leading geographical and statistical journals in the world. To carry out the propositions of the institute, I therefore move that a committee of five geographers be appointed by the chair to cooperate with a committee of the International Statistical Institute for the presentation of plans for demographic investigations in different countries.

AFRICA BETWEEN THE RIVER JUBA AND THE NILE

By A. DONALDSON SMITH, Philadelphia

In this paper I propose to give a general résumé of the most important results of the geographic exploration of the country lying between the Juba and the Nile. Although, owing to the dryness of the country and the warlike character of the natives, no regular trade routes probably ever existed, yet from the earliest times individual traders—Egyptians, Arabs, and coast natives—penetrated a considerable distance into the country. From these traders a little information leaked out, which, although hazy in the extreme as to detail and exactness, nevertheless enabled Ptolemy to write of the two great lakes beyond the "Mountains of the Moon" from which rises the great Nile, guided Count Teleki in the discovery of lakes Rudolf and Stefanie in the same way as it had guided Baker and Speke, and enabled M. d'Abadie to tell us something of the string of lakes extending southward from Lake Zouai.

A mass of literature has been published on the subject. Most of it is inaccurate and misleading to the explorer, but some points have since proved to be surprisingly near the truth. Bishop Wakefield collected from Somali traders at Kismayu much material concerning the Boran people, but I found this to be of little value except in regard to their belief in a protecting deity called "Wak" and a few other points of this character.

Baron von der Decken, who lost his life at the hands of the Somalis at Bardera, was the first to give us a definite knowledge of the lower Juba, and in 1892 Mr. William Astor Chanler explored the country from the Tana River to a point a little beyond the Guaso Nyiro. Some interesting maps were compiled by Mr. E. B. Ravenstein from the researches of M. d'Abadie, Borelli, Checci, and more ancient writers, such as Fra Mauro and the Jesuit Job Ludolf, who described a stream arising in the midst of the Abyssinian highlands and emptying into the Indian Ocean. As early as the tenth century a river, which was undoubtedly the Omo, was reported in Abyssinia flowing southward into an unknown valley, and more than a thousand years later Borelli

described this as flowing into Lake Schambara or Rudolf, a theory which Captain Bottego proved to be correct in 1895.

Since the expeditions of Captain Bottego and myself the country between the Juba and the Nile has been so thoroughly explored that our knowledge of it may be considered almost exact, except from the geological and ethnological standpoints. In these two latter fields much work is yet to be accomplished.

Captain Bottego and Prince Ruspoli anticipated me in 1892 in the discovery of the principal sources of the Juba, except the eastern tributaries near Sheikh, Mahomed. On two separate expeditions they followed the River Dawa to a point near its source and crossed most of the head streams of the greater river near their sources. My original work, therefore, may be said to have intersected theirs at right angles, and to have carried me to Count Teleki's line at Lake Rudolf and subsequently to the Nile. Besides investigating pretty thoroughly the great Boran plateau, I explored the lower Abaya region, followed the course of the Sagan River, and traversed the country north of lakes Rudolf and Stefanie, as well as that south of Rudolf to the Tana River.

In 1895 Cavandish's expedition passed along my line to Lake Rudolf and, crossing the Omo, investigated the conditions existing at the northern and western portions of the lake. This expedition was soon followed by Lord Delamere's journey to the lake and to Marsabit. This trip, which was made mainly for sport, resulted chiefly in a valuable lot of photographs of that region. The great work of that year and the next, however, was the exploration of the region between Lake Marguerite and the Omo River, the tracing of the latter to its mouth, and the discovery of some of the sources of the Sobat by the late Captain Bottego, whose untimely death we have so much cause to lament. The work of Captain Bottego's companions, L. Vanutelli and C. Ceterni, entitled "L' Omo," and published by the Società Geografica Italiana in 1899, forms a most valuable contribution to our knowledge of the valleys of the Juba, Dawa, Omo, and some of the tributaries of the Sobat in their entire length. It contains a description of Lake Marguerite and that so-called "Switzerland of Africa" to the west of the Sidama Range, which was only seen by me from a distance on my journey to Lake Abaya.

On the latter journey a little incident occurred to me which I will mention as a warning to other explorers, to show that although one may often be deceived by mirage and find no water where water is expected, yet the reverse may also be true. When I was on the most northern part of the Konso Range and was looking down on the beautiful blue waters of Lake Abaya, I saw beyond this lake, over a spit of yellow grass, the glimmering of what I thought to be another lake glistening in the sunshine, and I even marked its position in a sketch.

On going to another hill, however, I could see no trace of water to the north, owing to some rising ground on the narrow strip of land dividing Lake Abaya from Lake Marguerite. I then concluded that what I had first taken for water was an optical illusion, and as three of my escort of twenty-nine Somalis had just previously been injured by a rhinoceros and the rest were in a deplorably worn-out condition, I did not push on to ascertain the truth, only going along the eastern shore of Abaya to the channel leading from that lake, which I found to be one of the sources of the River Sagan. If I had not been so often deceived by the effect of mirage I should have managed, however, to have anticipated Captain Bottego in his discovery of Lake Marguerite. Any future traveler who will ascend to the top of the range of hills 10 miles south of Lake Abaya will be rewarded by a glimpse of the reflection from the larger lakes beyond, as they dazzled the eyes of the first incredulous white men who beheld it, and he will know that he is not deceived by an optical illusion.

On my first expedition, in 1899–1900, I passed from Egder, south of my former line, to the southern end of Lake Stefanie, and mapped a large extent of new country, obtaining views from certain mountain peaks that enabled me to pick up points with my theodolite as far north as the Sidama Range and as far south as Marsabit. I then noted the great wall which supports the Boran plateau near its southeast corner, but I was mistaken in believing this to extend to Marsabit. Captain Maud has recently found that the escarpment makes a sudden bend to the east only 5 miles south of the place where I descended it at Megado, whereas my eye had followed the line of the Huri Mountains, which begin but a short distance from the Boran wall, running near to the Rendile.

When I reached Lake Stefanie I found it had dwindled to one-half its former size, and Mr. James J. Harrison's expedition, coming along from Adis Ababa a few months later, discovered that not only Lake Stefanie but the Sagan and the lower Omo had completely dried up. Captain Welby's journey soon followed southward from Adis Ababa to Lake Rudolf, rounding the southern corner of the latter and thence proceeding through parts of the Turkana, Akara, Magoise, and Boma countries, which had never been visited before, to the Pibor and Sobat. On this expedition Captain Welby also discovered Lake Hora and otherwise added considerably to our knowledge of the Abaya district.

In 1900 Herr Oscar Neumann and Baron Erlanger made what may be called an exceptionally valuable double expedition from Zeila, via Adis Ababa, to the Zouai Lakes, Herr Neumann going thence to the Sobat system and Baron Erlanger to Lake Rudolf. On this expedition most of the lake problems were solved and much light was shed on the intervening country to the Pibor.

I will not dwell upon the upper Abaya region in detail, as it is out of

my province. I will merely state that, by the work of Neumann and several other explorers, the number and position of the lakes and the surrounding country have been considerably cleared up topographically, but there is still left between the different lines a great deal of country which is practically unknown. Including Lake Zouai and the lower Abaya, eight lakes have been discovered, and it is not unlikely that there are one or two smaller ones.

I shall mention in connection with this work also the names of d'Aragon, Count Wickenburg, and M. de Bourg de Bozas, the two latter of whom journeyed through to lakes Rudolf and Stefanie. Count Wickenburg found a considerable extent of undrinkable, salty water in Lake Stefanie, which no longer supports animal life. In turning southward from Lake Stefanie he discovered some new country which he describes as a vast, waterless steppe, mainly volcanic in character, of recent formation, from which arise various ranges and peaks. The Huri Range, running south from the Boran escarpment, which Count Wickenburg discovered, was already noted in my maps, but the Marsabit group was shown to contain two more lakes besides the one which I discovered. Captain Maud, who in 1902-3 traced the Boran escarpment, showed several smaller streams flowing southeastward from the Boran plateau toward the Juba, and gave us considerable new information concerning the Borans and their country. Passing again to the west of Lake Rudolf, I will note the expedition of Colonel McDonald in 1897-98. On this expedition a great deal of new country was mapped to the north of Mount Elgon as far as the Latuka Mountains. The interesting and practically unknown Karamojo natives and their country and the Latuka tribes, with whom Baker had formerly come in contact, were described with much detail. The country was found to be mountainous, some of the peaks rising to over 9,000 feet, and it is rich and well watered.

My last journey, in 1900, took me south of Captain Bottego's line, from the bend of the Omo River across the Musha plateau to the plain of the Sobat, at Magoise, near the point where the Pibor rises. Here I crossed Captain Welby's line of march and journeyed thence across the southeast corner of the great plain to Akara, the Berri Range, and Rejaf on the Nile.

On two expeditions Major Austin added much to our knowledge of the southern tributaries of the Pibor, although he did not settle definitely the most southern tributary, about which Captain Welby was so confused.

Having taken up briefly the history of the various expeditions in chronological order, I will now endeavor, in a general summary, to describe the country between the Juba and the Nile as a whole. The most northern section of the Boran country may be described as a very high, mountainous country, continuous with and a part of the Abyssin-

ian highlands; very fertile, fairly well watered, and temperate. The central and southern parts, which should be designated the Boran plateau, rise to an elevation of between 3,000 and 4,000 feet, are rough, more or less hilly, and thickly covered with a scrub growth of valueless trees and bushes, water being scarce. One mountain chain, which is a continuation of the Sidama Range, intersects the plateau from north to south, and here better conditions exist for grazing, but there is not enough water to afford hope of its ever becoming an agricultural country. Another range, inhabited by the Tertalla Boran, runs southwest from Abaya to the southern end of Lake Stefanie; and although this is a still better grazing country, there is almost the same lack of water.

Below the Boran escarpment which I have mentioned, stretching far away to the Tana and the few ponds near the mouth of the Juba, lies a great arid steppe, intersected by the Guaso Nyro and a group of smaller streams flowing into the Juba, which are like long oases in the otherwise forbidding desert. In the west the short Huri Range extends southward to Marsabit, but, with this exception, there is only an occasional barren mass of rocks to break the monotony of the plain. I heard of a small river that runs eastward from the Huri Range, and Captain Maud saw several rivulets running southeastward from the escarpment that in all likelihood empty into the same stream, which finds its way to the Juba near Bardera. The waters of the Guaso Nyro probably find a subterranean passage from the Lorian swamp in the same direction. Between Lakes Stefanie and Rudolf, on the Amar Koki hills, one stream at least has been seen by so many travelers, including myself, at different seasons to flow above ground for about 15 miles before disappearing under its sandy bed that I believe this water to be perennial, and there are probably two or three other smaller perennial streams which show their heads above ground for a short distance only, but which could be used for irrigation if their waters were carried a long distance from their present rocky bed. All this country which lies south of the Dawa River and the northern end of Lake Rudolf, in the sphere of the British East Africa Protectorate, will never be of importance, commercially or agriculturally. It is true that a large extent of most fertile ground could be cultivated by a system of irrigation along the rivers, but the climate is so unhealthful that I do not believe that any great number of natives will take up their abode there for any length of time. The other dependable waters are so few and far between, such as the Lakes of Marsabit and the Boran pools and wells, that they may be regarded only as affording good points for administrative posts. If the spring and autumn rains could be depended upon, it would be a different matter; but, as has been shown recently, these sometimes are missed for several consecutive seasons, so that water could not be conserved for a

sufficient time. The source of these rains is the northern trade winds, which sometimes have no moisture left in them after passing over the Abyssinian highlands. After we pass around the northern end of Lake Rudolf and through the country in the direction of the mouth of the Sobat, we find a wretched desert for the most part, broken by the Musha plateau, with its ragged, volcanic mountain chains. This plateau divides only incompletely the ancient bed of Lake Rudolf from the Nile basin, and its southern end is marked by a wall passing almost perpendicularly to a plain, where once in all probability the waters of the Nile mingled with those of the lake. The Musha plateau, which was first explored and described by myself, is very like the Boran country, only better watered and a little more suitable to agriculture. In all the maps made previous to my expedition in 1900 a great river was given, running from the country west of Turkanna into Sobat, and several smaller streams were also laid down as running from south to north, either into the Sobat or Nile; but to my sorrow I found nothing, either south or west of the Pibor, but a vast desert of dry, cracked mud with an occasional butte lifting up its scorched and lonely head, and a few river beds containing water in pools, such as those near Magoise and Akara, running a very short distance from the hills and disappearing entirely in the plain.

I ventured so far out on the desert that I and my entire outfit came very near perishing, and I saw enough of it to make me believe that no animal, human or other, will ever cross it. Where the Musha hills join with the western extension of the Abyssinian highlands, which I saw from a distance and described as the Galo Mountains, we find some of the head streams of the Sobat, and these, passing through the northwestern corner of the Sobat plain, transform that part into a garden in places, with considerable forests and occasional large swamps. Here many natives are engaged in agricultural pursuits. On the south of the Great Desert, we find the long lines of mountains running north from the Uganda highlands and abutting gradually into the plain. First the Turkanna Range, then the low hills of the Akara, farther to the west the terminations of the Latuka highlands, and last of all, near the Nile, the hills of Berri. All these low hills stretch from a high, mountainous country, with the fertile plains of Karamojo in the center, lying between Lakes Rudolf and Victoria Nyanza. The country of the Turkanna, Akara, Karamojo, Latuka tribes and Kararrondo is fairly thickly populated with agriculturists as well as by nomads, and there is a far better outlet for Europeans here than in any country I have described, excepting Abyssinia. Sometimes droughts occur, but the rains are brought by monsoon winds which are regular enough to insure against famine if the water is husbanded in artificial reservoirs, and the soil is rich and capable of

raising almost anything in abundance. The origin of the Pibor seems to me to be fairly settled from the work accomplished by Bottego, Welby, and Austin, coupled with my discovery of the stream flowing northwest into the Sobat near Magoise.

Undoubtedly the stream which Major Austin followed from its mouth, at about 7° 50′ north, down to the Boma plateau north of the Mushas, was the same stream which Bottego had explored and which Welby found flowing into the Pibor from the southeast. The Pibor or Ruzi 2d of Welby (Neubari of Austin) rises in the hills a little northeast of the Magoise in latitude 5° 45′ north, longitude 34° 40′ east, while the Akobo rises from the Galo Mountains, not far from the Omo River, in latitude 6° 20′ north, longitude 35° 30′ east, approximately. Where this passes down into the Sobat plain it is a degree north of the Pibor, and between the two several smaller streams debouch onto the plain from the Boma hills in the rainy season, the more northerly flowing into the Akobo, but the one or two on the south flowing to the head stream of the Pibor, which I have described. In the rainy season small wadies pour the waters which they drain from the plain into the Pibor on the west, and several of these uniting may form at times a large stream which flows into the Pibor on the south. But as this will contain water only in flood times we should consider the stream near Magoise the perennial source of the Pibor.

The country between the Juba and the Nile is so thickly populated with animal and plant life that the natural history of the region would be too broad for me to discuss in this paper. Of birds alone, there are more than 1,000 varieties. Over one-half of these are migratory, but some of them are confined to little areas 50 miles square, while others occupy large zones. At Lake Rudolf we have the most marked transition between the Somali and the South African types. While there is a great variety of enormous trees, such as the baobab, sycamore, tamarind, and, in the mountains, firs and cedars, the quality of timber is poor. Bamboo has been found only at one or two places, such as in the neighborhood of Kaffa and near the headwaters of the Nile. Out of about 20 varieties of snakes, I understand that there are not a half dozen that are poisonous, and these do not strike unless very hard pressed. There are many varieties of fish, usually of the catfish type, but with the exception of the different varieties of the chromos, which are not unlike our small black bass, they are too muddy flavored and fat to be desirable by any other than the ill-fed explorer.

The matter that is of the greatest scientific importance has been, I am sorry to say, the least studied—that is, the ethnology. Here is a most valuable, and, I will say, almost untouched field for the patient investigator who will give a long time to his work. Although many tribes have been seen and visited, no explorer has yet remained with a

single tribe long enough to learn its language, customs, relationship, and origin, except in the crudest form. Every explorer, including myself, has, however, given to the world plenty of guesses and statements emanating from the minds of interpreters. Sometimes, after great labor, some slight knowledge has been gained of a tribe and a small vocabulary of its language has been made, but no one has stopped long enough anywhere to accomplish much except among the Somalis, Gali, and Masai. We find the Somalis inhabiting the country extending along the Juba from Kismayu to the Dawa, together with a few thick-set people of Bantu stock, who are held by the Somalis in a mild state of slavery. The Somalis also extend inland to Banissa, where the Gerri Liban, a division of the Borans, take their place. The Borans, who extend thence all over the plateau I have described to the borders of Lake Stefanie, are a fine race physically and more civilized than any except the Somalis. They are light colored like their brother Galla on the Tana and appear to be very like these in customs and religious belief. I agree with Bishop Wakefield in his statement that they worship a protecting deity whom they call "Wak," and as they look to him as the provider of all good things, like our red Indians, they naturally worship and sacrifice to him, under the shade of some great tree. Captain Maud believes they try to appease the evil spirit that dwells in a tree, and he has given us an account of their allowing all their children born within the first eight years of wedlock to die in the bush, as a peace offering.

I am not attempting to touch much on any tribe, confining myself only to a few points as they appear in the light of recent investigation. It would appear that the whole country from Adis Ababa to Lake Victoria was once peopled by aboriginal tribes, including the Pigmies, that occupied small districts and spoke totally different languages; some physically and socially alike, and others showing great differences. In consequence of wars, intermarriages, and migrations, we find customs and physical characteristics changed in some instances where the original language has remained unaltered, and vice versa.

Major McDonald, who made an extensive vocabulary of the Latuka people, found their language very like that of the Masai and Shilluk. The Magoise and Katua, whom I discovered on the eastern edge of the Sobat plain, belong to the Nilotic group, and in the light of recent discoveries along the Sobat, the former seem to belong to the Annuaks or Shilluks, living west of Kaffa, while the Katua have the characteristics of the Nuers or Dinkas, living on the Khor Filus, a river recently explored by Capt. H. H. Wilson, which runs from Bor, on the Nile, to the Sobat, near the latter's mouth. Both of these latter tribes sleep on the ashes of bois de vache, and build excellent huts, sometimes raised on piles. Again, I found the word "oum" for ele-

phant to be used by the Nuers, Katua, and the Berri. Neumann discovered that the language of the Annuaks was scarcely distinguishable from that of the Kavirondo people on the shore of Lake Victoria.

The Akara, living south of the Magoise, I found to be akin to the Katua, although they have a different language; but I succeeded in procuring only a very small vocabulary of these two tribes. It seems to me beyond question that the Sobat plain on every border is peopled by the one Shilluk-Dinka or Nilotic group. In their manner of personal adornment the Magoise are like the Turkana. They wear the same round cutting knife on the wrist, carry the small wooden club with a sharpened point incased in leather, to be found only among the latter, and wear their hair in the same way, although they do not in any other respect resemble the Rudolf group. I would class the Karamojo, the Turkana, the Elgume, the Murle, Mursa, Mushas, and Kerre as one distinct Lake Rudolf group, apart from the Masai, although in language they differ often from one another. Their features are more Hamitic, and they are taller than the Masai and wear their hair in the form of a long chignon extending varying distances down the back and adorned with ostrich plumes or long wavy reeds, and besides the other ornaments I have described in the Magoise they usually wear an ivory or brass rod or reed stuck through their lower lip. The distinctive characteristic of the Masai, the large hole in the lobe of the ear and the circle of small earrings, is never found among this Rudolf group, excepting in the case of the pure-blooded Wakwafi or Masai, who have migrated in recent years and who are rapidly infusing their language and customs among their hosts. A high forehead, great length of limb, and narrow pelvis are characteristics of the people about Lake Rudolf. Many Masai inhabit the Rendile country at the southern end of the lake, but these can be seen to differ from the Turkana almost as much as they do from the superbly proportioned and light-colored Rendile, who are of Somali extraction.

To the north of Lake Stefanie is another distinctly different group which I believe to be principally of Pigmy extraction. These include the few naked Arbore, living among the Amar Koki, their very light neighbors on the north, the Dume, whom I described in 1894, and the Bunno and Male to the north of Kerre on the Male River. All these people have a lower type of features, live more primitively, use poisoned arrows, and in their headdress, as well as in their size, differ widely from their neighbors. To the north of the Pigmy group we have another very interesting people in the Sidama and the Doko. Herr Neumann is probably nearly correct when he classes the Sidama as one group with the Jam Jam, Walamo, Barodda, Kosha, and Male people of remote origin, and more or less mixed with Galla, but a most remarkable circumstance was his discovery of a people of pure

Bantu stock near Bonga, in Kaffa, which includes the Doko and Gardulla. When we find one small nucleus of people, such as these Doko and Gardulla, isolated many hundreds of miles from territory inhabited by their forebears it is easy to see how intervening tribes may be of a very mongrel breed. We even find a few Somali words as far north as these Doko.

These tribes should be studied at once, for within the next few years they will become so Abyssinianized that they will almost entirely lose their identity.

RÉCENTES EXPLORATIONS SCIENTIFIQUES DANS L'INTÉRIEUR DU SOUDAN

Par AUG. CHEVALIER, Paris

Jusqu'au milieu du dix-neuvième siècle, les connaissances sur l'Afrique centrale ont été des plus incomplètes. Les renseignements recueillis par Léon l'Africain, Hornemann, Mungo Park, René Caillé, Oudney Denham et Clapperton, les frères Lander, etc., ne se rapportent guère qu'à la géographie et à la sociologie. De 1850 à 1880 pendant que Burton, Livingstone, Speke et Grant, et Stanley étudient l'Afrique orientale et les contrées situées au sud de l'équateur, des explorations poursuivies dans le centre de l'Afrique par les voyageurs allemands Barth, Ed. Vogel, Nachtigal, Schweinfurth, Junker fournissent un abondant faisceau de renseignements relatifs non plus seulement à la géographie proprement dite mais encore à l'ethnographie, la sociologie, la linguistique, l'histoire naturelle, la climatologie. Mais les données précises manquent encore pour une grande partie du Soudan intérieur, en particulier pour la boucle du Niger et les contrées au sud du 11^e parallèle arrosées par le Chari et ses affluents. Les Français devaient combler ces lacunes.

La pénétration française vers l'intérieur de l'Afrique commence vers 1880 et les grandes chevauchées de nos voyageurs se poursuivent vers le centre de l'Afrique jusqu'en 1900. Nous citerons seulement les plus célèbres: Galliéni, Binger, Monteil, dans la boucle du Niger, Savorgnan de Brazza et ses collaborateurs au Congo, Crampel, Dybowski, Liotard, Marchand dans l'Oubangui, Maistre et ses compagnons dans le bassin du Chari, Mizon entre la Benoué et la Sangha. Enfin, en dernier lieu, les trois missions Foureau-Lamy, Gentil-Bretonnet, Joalland-Meynier qui ont pour résultat de souder en un seul bloc les possessions françaises de l'Algérie et de l'ouest africain au Congo et au Tchad.

La plupart de ces voyages ayant un but essentiellement politique furent poursuivies souvent à la hâte et ne purent pas toujours rapporter de nombreux renseignements précis sur les contrées traversées. Nous devons cependant une mention spéciale aux beaux récits de Bin-

ger, de Maistre et de Foureau si riches en documents de toutes sortes et aux magnifiques collections d'histoire naturelle rapportées du Congo et du haut Oubangui par Chollon, Jacques de Brazza et J. Dybowski. Pourtant cela ne suffisait pas, la conquête terminée il fallait inventorier avec méthode les productions de ces contrées nouvelles, en étudier la géographie avec plus de précision, en faire connaître les habitants, les animaux, les plantes, etc. C'est au général de Trentinian que revient l'honneur d'avoir fait commencer cette tâche à laquelle nous avons collaboré depuis six ans et qu'il faudra de nombreuses années pour terminer.

En 1898 le général de Trentinian constitue une mission composée d'une quinzaine de membres chargés de faire connaître les ressources du Soudan français et d'étudier les meilleures conditions de leur exploitation. Le but de cette mission étant économique, il fait surtout appel à des ingénieurs et des commerçants, mais il nous charge cependant des recherches scientifiques relatives à l'histoire naturelle et à l'agriculture tropicale. C'est au cours de ce voyage que furent faites les premières études relatives au coton africain et qu'il fut permis de prévoir l'avenir réservé à la culture de ce textile sur les bords du Niger et du Sénégal. C'est aussi au cours de ces travaux que fut démontrée l'unité d'origine du caoutchouc soudanais fourni par une liane apocynacée le *Landolphia owariensis* A. DC. produisant à lui seul en Afrique environ 2,000 tonnes de caoutchouc d'une valeur de 15 millions de francs.

À la fin de l'année 1899, une nouvelle mission fut constituée pour poursuivre au Sénégal ce qui venait d'être fait au Soudan: M. le docteur Lasnet s'occupait de l'ethnographie, M. Cligny de la zoologie, M. P. Rambaud de la géologie et nous même de la botanique et des ressources forestières et agricoles.

Mais il restait encore à étudier une portion importante du Soudan, comprenant le bassin du Tchad et les hauts affluents de l'Oubangi, la moins accessible de toutes les régions soudanaises et la plus mal connue. En 1902 le gouvernement français voulut bien nous donner les moyens d'action nécessaires pour accomplir cette tâche, et grâce aux précieux concours de l'Académie des inscriptions et belles-lettres et du Muséum d'histoire naturelle de Paris, il nous fut possible de nous adjoindre trois dévoués collaborateurs: M. Courtet, officier d'administration d'artillerie coloniale, chargé des recherches relatives à la topographie et à la géologie, le docteur Decorse, médecin de l'armée coloniale, chargé de former des collections ethnographiques et zoologiques, Martret, ancien élève de l'École d'horticulture de Versailles, qui devait créer un jardin dans le Haut Oubangui pour l'introduction de toutes les plantes tropicales utiles.

Pendant vingt mois la mission Chari-lac Tchad poursuivit ses travaux à travers l'Afrique centrale sur un parcours de 6,000 kilomètres,

visitant en particulier les contrées inexplorées situées entre le Chari et le bassin du Nil. Les documents et les collections qu'elle a rapportées permettent d'établir une liaison entre les bassins soudanais tributaires de l'Atlantique et le bassin du Nil si bien exploré au point de vue de l'histoire naturelle par G. Schweinfurth.

À l'aide des données que nous avons recueillies durant toutes ces missions, données encore imparfaitement classées, nous pouvons cependant présenter une première vue d'ensemble sur le Soudan.

GÉOGRAPHIE PHYSIQUE

Le Soudan est une immense région très naturelle formant l'intermédiaire entre la forêt vierge équatoriale et le désert du Sahara. Il s'étend depuis l'Atlantique jusqu'au massif Abyssin et par le sud du pays somalis il rejoint l'océan Indien. Constitué par des plaines d'argile, des plateaux de latérite ou des monticules et des collines de roches anciennes, il est sans grand relief. Seul le bouclier du Fouta-Djalon, les sommets de la haute Côte d'Ivoire, les hautes terrasses de l'Adamaoua présentent des points dépassant 2,000 mètres d'altitude. Aux confins des trois grands bassins Oubangui, Chari, Nil, la hauteur au dessus du niveau de la mer atteint à peine 900 mètres. Enfin l'altitude moyenne de la plupart des provinces du Soudan est comprise entre 250 et 450 mètres. Partout sévit une saison sèche qui dure quatre ou cinq mois dans le sud, mais peut durer neuf ou dix mois près du Sahara. Pendant cette saison la végétation herbacée se dessèche et les savanes incendiées annuellement par l'homme sont la proie des flammes et restent dénudées jusqu'à l'arrivée des premières pluies qui surviennent de mars à juillet suivant les zônes. L'assèchement de la zône nord est progressif et peu à peu le climat saharien empiète sur le Soudan. Le Chari, après avoir été tributaire de la Méditerranée, est devenu un bassin fermé par suite de l'assèchement de son cours inférieur.

GÉOLOGIE

Le sol est essentiellement constitué par des terrains éruptifs anciens (granits, granulites, porphyres), des roches de la série cristallophyllienne (gneiss et micaschistes) et des terrains primaires anciens (schistes, quartzites, marbres) dont il est impossible de préciser l'âge en l'absence de tout fossile. Ces derniers terrains sont plissés souvent dans une même direction générale, parfois relevés à la verticale et fréquemment traversés par des dykes de diabase et des filons de quartz. En certaines régions, comme au Fouta-Djalon, dans le haut Niger, la haute Volta, le pays de Snoussi (haut Chari), les terrains précédents sont surmontés par des bancs alternatifs de poudingues et de grès fins en couches très horizontales dont l'épaisseur totale peut atteindre 100 mètres de hauteur. Ces grès dépourvus de fossiles ont été rapportés avec quelques doutes

au permo-carbonifère, mais la roche qui domine à la surface du sol dans tout le Soudan est la latérite, sorte de grès ferrugineux riche en limonite, à éléments souvent assez grossiers pour constituer un véritable poudingue.

Au nord la latérite est remplacée par des argiles rouges ou ocracées, compactes, recouvertes de sables au contact du Sahara. Dans les régions avoisinant la côte, de même qu'en plusieurs points du Sahara (région de Tombouctou et région de Zinder), la mer tertiaire (calcaire grossier) s'est avancée sur le continent soudanais. C'est aussi exclusivement aux deux extrémités de ce continent (Sénégal et Somaliland) et dans la région saharienne limitrophe (Aïr et Tibesti) qu'ont eu lieu, postérieurement, des épanchements volcaniques.

FAUNE

La plupart des mammifères qui peuplent actuellement les steppes et les savanes herbeuses du Soudan sont les congénères de ceux qui vécurent en Europe à l'époque miocène. L'éléphant de plus en plus chassé pour l'ivoire aura bientôt disparu; au contraire, l'hippopotame pullule encore dans certaines rivières. De nombreuses espèces d'antilopes vagabondent en troupeaux denses à travers les steppes et la girafe est commune dans le bassin du Chari au nord du 9^e parallèle.

Les carnassiers (lions, hyènes, cynhyènes, panthères, etc.), ne sont pas moins abondants que les herbivores. Les zèbres sont des animaux de l'Afrique orientale et n'ont jamais été trouvés dans le Soudan proprement dit. Il est de même du célèbre okapi trouvé exclusivement usqu'à présent dans les territoires belges voisins de l'Ouganda. L'étude des autres groupes de vertébrés et des invertébrés n'est pas assez avancée pour que nous puissions tirer des conclusions sur leur répartition. Citons l'abondance dans beaucoup de régions du Soudan de plusieurs espèces de Glossina ou mouches tsé-tsé propageant les maladies à trypanosomes si fatales à l'élevage du bétail et dont une espèce, la *Glossina palpalis*, serait la cause de la si curieuse maladie du sommeil qui sévit dans plusieurs districts du sud du Soudan.

FLORE

La végétation est loin d'avoir l'exubérance qu'elle possède dans la forêt équatoriale, et la plupart des arbustes sont soumis à un repos hivernal et perdent leurs feuilles après la saison des pluies. Nous ne pensons pas qu'il existe plus de 4.000 espèces de phanérogames dans tout le Soudan. Encore ce nombre comprend-il une grande quantité d'espèces qui ne sont pas encore nommées. Les cryptogames terrestres, à l'exception des champignons, font presque complètement défaut dès qu'on approche à quelques centaines de kilomètres du Sahara.

En allant du nord au sud on peut distinguer au point de vue de la végétation, trois zônes très distinctes dans le Soudan:

1°. La zône sahélienne est caractérisée par un sol sablonneux, nu sur de grands espaces, occupé ça et là par de maigres steppes peuplées de buissons épineux d'Acacia de Balanites, de jujubiers sauvages, de Capparidées. Par place, la silhouette rameuse d'un palmier Doum (*Hyphæne thebaica*) se dresse au bord des talus tapissés d'Ipomæa et d'Hibiscus.

2° La zône soudanienne couverte de savanes et parsemée de grands arbres espacés non épineux, parmi lesquels dominent les nétés (Parkia), les karités (Bassia), les Combretum, les Terminalia, les Vitex, les futaies de bambous d'Abyssinie, etc. L'ensemble a l'aspect d'un magnifique parc dont les gazons sont formés de hautes graminées, parmi lesquelles les Andropogon et les Panicum. Le Borassus a remplacé l'Hyphæne. Les fleuves et les rivières sont environnés d'un étroit rideau d'arbres.

3° La zône guinéenne présentant également la végétation à aspect de parc, mais à arbres plus élevés et plus rapprochés. De nombreuses monocotyledones arborescentes: Musa, Dracæna, Pandanus, palmiers, Elæis, Raphia, Calamus croissent dans les lieux frais et boisés, mais ce qui caractérise surtout cette zône ce sont les magnifiques galeries de végétation forestière bordant les cours d'eau aux sous-bois d'Amomum, de Costus et d'autres scitaminées, aux arbres gigantesques enlacés de lianes. Ces galeries forment une transition très nette entre les savanes soudanaises et la forêt vierge équatoriale.

PRODUCTIONS FORESTIÈRES ET AGRICOLES

À chaque zône correspondent aussi des productions utilisables différentes. Le nord est le pays des Acacias qui produisent la gomme arabique. Dans la zône moyenne croît le Bassia qui fournit le beurre de Galam et dont le latex contient une substance guttoïde. C'est aussi dans les parties les plus arides de cette région que vit le *Landolphia heudelotii*, la liane à caoutchouc par excellence. Enfin d'autres lianes à tiges naines brûlées annuellement par les incendies d'herbes fournissent par leurs rhizomes ce que l'on a nommé le caoutchouc des racines. Le *Khaya senegalensis* qui produit l'acajou du Sénégal est aussi un arbre caractéristique de la contrée.

La zône guinéenne héberge de grandes lianes à caoutchouc, en particulier le *Landolphia owariensis;* le *Funtumia elastica* Preuss, l'arbre à caoutchouc du Congo y pénètre à peine. Il en est de même des colatiers, caractéristiques de la forêt équatoriale mais dont la culture réussit dans la zône guinéenne. Enfin, cette zône est par excellence le pays des caféiers sauvages dont une espèce, le *Coffea excelsa*, découverte par la mission Chari-lac Tchad, en Afrique centrale, constitue

un arbre de 15 à 20 mètres de haut, produisant un excellent café à petit grain.

Chaque zône du Soudan a aussi ses cultures: dans le nord les habitants se nourrissent de Penicillaria ou petit mil; dans la partie moyenne c'est le Sorgho qui est la base de l'alimentation; enfin, dans le sud il est remplacé par les rhizomes et tubercules alimentaires: manioc, ignames, patates, Colcus plus ou moins analogues comme composition à la pomme de terre.

Au Sénégal, c'est dans la partie correspondant à la zône sahélienne que réussit le mieux la culture de l'arachide, une des principales sources de richesse de l'Afrique occidentale.

LA PRÉHISTOIRE ET LES HABITANTS ACTUELS

On a trouvé des traces de l'industrie humaine à l'époque de la pierre éclatée seulement en Guinée française. Au contraire l'âge de la pierre polie a laissé de nombreuses traces au Sénégal, dans la boucle du Niger, dans le nord du Baguirmi, au Ouadaï, etc.

Les fouilles poursuivies dans la région de Tombouctou par le lieutenant Desplagnes et celles du docteur Decorse dans le Bornou allemand ont fourni de précieux renseignements sur les hommes qui peuplaient le nord du Soudan avant l'invasion arabe.

L'étude des diverses races blanches soudanaises actuelles (Berbères, Arabes du sud et Peuls), et celles des innombrables tribus de Nègres et Négroïdes dispersés sur toute la surface du Soudan nous a fourni d'intéressantes indications sur les affinités de ces races et leur sociologie, mais il serait prématuré d'en tirer des conclusions avant le dépouillement des notes et des mensurations faites par le docteur Decorse au cours de la mission Chari-lac Tchad.

Nous espérons pouvoir mettre bientôt à jour les travaux se rapportant aux différents chapitres énoncés ci-dessus. Nous avons voulu seulement énoncer ici les principaux résultats acquis au cours de nos missions précédentes.

FRENCH CONQUEST OF THE SAHARA

By CHARLES RABOT

Editorial secretary of "La Géographie," member of the Council of Société de Géographie de Paris

To traverse the Sahara from north to south, to join Algeria to the Sudan through the great desert of north Africa, and to subjugate the nomads who wander through that immense region have been among the principal aims of France in recent years, and these ends she has at length attained at the price of long and persevering effort. The hostility of the Touaregs was for a long time an obstacle. Established in the oases scattered over the Sahara, these Berber fanatics and brigands were accustomed to scan the whole desert, and as soon as they spied a caravan to fall upon it to rob and massacre. Often, too, they were wont to attack the tribes of the extreme south of Algeria, who had already submitted to French influences.

After the disaster to the Flatters expedition in 1881 and several other outrages committed by the Touaregs, the French military authorities postponed for a while all further efforts to penetrate into the Sahara and remained simply on the defensive.

During this period of official inaction M. Foureau made a series of very profitable expeditions in the desert regions south of Algeria. From 1883 to 1897 he traveled no less than 13,200 miles, of which 9,600 were in regions entirely unknown.

Not only did M. Foureau notably augment our geographic knowledge by this journey, but he inaugurated a mode of traveling which has been very serviceable in the exploration of the Sahara. Instead of being accompanied by a heavy caravan, as were preceding expeditions, this traveler adopted the mode of life and transport of the natives, taking with him only a few faithful Arabs. His little troup was mounted on "meharis," used by the Touaregs—rapid camels, which are to the ordinary camels of the caravan what race horses are to cart horses. Thanks to the mobility of his caravan, M. Foureau could make long excursions without being attacked by the Touaregs. Meanwhile, from 1890 to 1892, a French officer, Colonel Monteil, accomplished the crossing of the Sahara from Tchad to Tripoli by the caravan route.

The French, however, had never abandoned the idea of a junction of Algeria to the Sudan. In 1896 a member of the Geographical Society, M. Renoust des Orgeries, encouraged this idea by giving the society $50,000 to organize an expedition to carry out this programme, and in 1899 M. Foureau received permission to traverse the Sahara and to make his way through the desert to the French possessions in central Africa. To insure the safety of his caravan and to compel a respect for the French flag from the brigands of the Sahara, the Government gave M. Foureau a numerous military escort, commanded by Major Lamy.

This Foureau expedition started from Ouargla (in south Algeria) at the end of October, 1898, and a year later (November 2, 1899) arrived at Zinder, at the northeast extremity of French Sudan. In the April following, after having gone round Lake Tchad by the north and east, the expedition had effected a junction with the French troops upon the Chari, the principal affluent of the Tchad.

The march of the expedition was very slow and painful in consequence of the enormous caravan track behind it. Part of its camels soon succumbed to the fatigues of the journey, and it was impossible to purchase new beasts of burden from the nomads. The Touaregs, confident of their strength, threw themselves at various times against the little troop, but, finally having learned in these encounters that they could not be victorious, abandoned active hostilities and limited themselves to creating a complete dearth of supplies around the explorers. It was only through the energies of M. Foureau and of the military chiefs that the expedition was able to get along at all.

The slowness of this journey has had very favorable results from the scientific point of view. It has permitted M. Foureau to acquire a very complete knowledge of the country and to gather a very rich harvest of observations pertaining to all fields of geography. A great work setting forth these scientific observations is in course of publication and is being offered to all important geographic societies.

The Foureau expedition opens a new era in the French penetration of the Sahara. At the moment when this expedition was setting out the French Government, abandoning the merely defensive policy observed since the Flatters expedition in 1881, decided to extend farther southward the zone of French influence, which then did not pass 30° north latitude. On the 28th of December, 1899, M. Flamand, a naturalist, was instructed to make a study of the region which it was proposed to annex, and was attacked at Insala. Immediately the French troops advanced on their "meharis," commanded by Captains Germain and Pein, two brilliant Sahara officers. Some months later the French occupied the chain of oases of Gourara, Touat, and Tidikelt, more than 300 kilometers in length, which runs along the subterranean

courses of rivers descending from the high plateaus of Morocco and Algeria. In this way the French had advanced nearly half the distance from the Mediterranean to the northern curve of the Niger at Timbuctoo.

This military advance has had interesting results from the point of view of geography. An excellent map on the scale of 1:250,000 has been made by Lieutenant Nieger of the whole region of Touat and Tidikelt, hitherto imperfectly known. Moreover, M. Flamand has published interesting notes on the morphology and geology of this part of the desert. To insure protection of the oases thus acquired against the incursions of the Touaregs, the military authorities recognized the necessity of abandoning the old policy of simply remaining on the defensive. In order to assure the tranquility of the country, it was necessary at the first attack from the brigand tribes to pursue them vigorously through the desert, and not to give up until a sharp lesson had been inflicted.

This result could be attained only by a very mobile and well-acclimatized troop. It was decided therefore to undertake the creation of troops mounted on "meharis" and composed of natives under the command of French officers. This organization was modelled after the famous "dromedary companies" organized by Bonaparte in Egypt, and the "camel corps" recently adopted in the Sudan by the British army.

Since that time the French troops have been on an equality of speed and mobility with the Touaregs, while their superiority of arms insures victory even against superior numbers.

These Saharan troops once organized, the officers commanding the extreme southern posts on the Algerian frontier undertook long excursions into the Sahara, traversing and surveying vast unknown regions and at the same time acting as a vigilant police. On March 26, 1901, the Touaregs having come to rob the people of Tidikelt, Lieutenant Cottenest started with 130 native troops and reached the mountain mass of the Hoggar and inflicted a severe lesson upon the brigands, returning to Insala after having traveled 1,000 miles in sixty-two days in a country entirely hostile. The same year, from the 16th of May to the 15th of June, Major Laperrine explored the Mouydir, a plateau surrounded by valleys from 200 to 300 meters deep and containing an abundance of water, wood, and excellent pasture.

Some time later, in 1902, Lieutenant Guilho-Lohan returned to the Hoggar plateau and pushed south to 22° latitude north. In 1903 Lieutenant Besset made a journey of 750 miles in the south, and some months later Major Laperrine, accompanied by Professor Gautier, directed a new reconnaissance in the Mouydir and the Ahnet. At the same time Captain Pein made a trip round the Temassinine, in the region situated farther east.

These different expeditions completely transformed the situation in the Sahara. The Touaregs, finding themselves chastised for the smallest act of rapine and always overtaken in their haunts, gave submission to Captain Metois, commanding at Insala. Only the tribe of Azguers, which wanders in the eastern Sahara, had as yet refused to accept French domination.

Accordingly, a new and decisive operation was undertaken. At the commencement of February, 1904, Major Laperrine, quitting Insala at the head of a troop of "meharistes" and taking his route southward, succeeded in traversing the Sahara and meeting a second troop of "meharistes" which had set out from Timbuctoo. In this way was effected the junction of Algeria with the Niger, previously accomplished by M. Foureau, but now by a more eastern route.

In this expedition Major Laperrine was accompanied by an astronomer, M. Villate. From a geographical point of view these expeditions have had very important results. The officers who commanded them have employed precise methods and brought back numerous observations of interest. As a result of the reconnaissance in which he took part in 1903, Professor Gautier has made a geological map of Mouydir and Ahnet, in the very center of the Sahara.

The junction of the parties from Insala and Timbuctoo took place on April 18, at the well of Tioniaoune, in 20° 10′ north latitude. The party from Algeria, under Commandant Laperrine, had come through Inzize and Timissao. After he succeeded in joining hands with the southern party, the commandant pushed a little farther south, as far as the well of Tin Zaouatem, in 19° 57′ north latitude, but soon resumed the journey northward to Insala, following a fresh itinerary. Scarcity of water and the heat (it was May) made the homeward journey very trying, part of the men having to travel as far as 320 kilometers with hardly any water. News received from this expedition points to the extension southward of the volcanic formations discovered by M. Gautier in Mouydir.

Thanks to M. Foureau and to the officers commanding the posts of the extreme south of Algeria, considerable progress has been accomplished by the new method of exploring the Sahara by the employment of "mehara" (singular of "mehari"). This camel can bear, besides his rider and his arms and accouterments, thirty days' victuals and two skins of water. With this load he can march from 3 to 3½ miles an hour and amble at a pace of 5 miles. In the trip made in 1903 by Commandant Laperrine and Professor Gautier 69 miles were traversed in twenty-nine hours.

One has no need for anxiety as to feeding the mehari; the desert flora suffices for its food, and in summer it can endure five days without drinking, while when plants are green it can go without water for eighteen or twenty days.

By this method of exploring the Sahara, M. Foureau and these French officers have there made progress as important as that effected by Nansen in his Arctic exploration. By adopting the means of locomotion and of existence of the Polar peoples, the Norwegian explorer gained a memorable victory. In the same way, by borrowing from the inhabitants of the Sahara their mode of life and locomotion, the French have triumphed over the obstacles which the nature of the soil and of the inhabitants had set against the exploration of the great desert of northern Africa.

METHODS OF EXPLORATION IN AFRICA

By Maj. A. ST. HILL GIBBONS, Bude, England

Few problems are incapable of solution by more than a single method, and such is the constitution of human judgment that opinion is usually divided as to the best means of attaining any given object. In the case of opinions founded on hypothesis as distinguished from those based on positive data, it is seldom that a public verdict—even though arrived at by an overwhelming majority—can be definitely accepted as final, for the opinion of a community, and in fact of the world at large, is constantly subject to modification, sometimes for reasons obvious to all, sometimes as the result of influences more subtle and obscure.

Such being the case I recommend to the consideration of the congress a principle which I submit is inseparably wrapped up with the best interests of geographical research in the Africa of to-day—a principle which hitherto has received but little attention at the hands of geographers at large, and still less, if any at all, by the general public.

In the school days of most of us an intelligent boy could acquire in a few hours all that was to be learned from the map of Africa—a huge yellow continent fringed by a coast line on which alone was to be found any information of a definite nature. The life-long labors, the enthusiasm, and the splendid successes of David Livingstone were already awakening throughout the world a latent interest in a continent the interior of which was better known in the days of Ptolemy than during the boyhood of our own fathers.

The development of a great and attractive idea is seldom allowed to lapse with the life of the initiator.

Thus the career of Livingstone sowed the seeds of other careers and added to the history of progressive civilization illustrious names which will retain their luster until the world forgets the meaning of the word manhood. The last of this first generation of eminent modern explorers died only a few months ago and has left on record a career scarcely less remarkable for obstacles met and overcome than

for the importance of the political and geographical results springing from it.

The exploration of an unknown continent, such as was Africa two generations ago, must necessarily proceed by stages. First, the main features of the continent must be discovered, its general physical construction, the main river systems, the character of the inhabitants, and so forth. In fact a general knowledge of what the continent contains must be acquired. To attain this object it is necessary that expeditions should dive deep into the depths of the unknown, should draw on the map long lines which will intersect what may be described as the main skeleton and arteries of the body to be constructed.

With Stanley's last great trip across the continent this stage was practically developed, and the time had arrived when, in my humble opinion, the second stage was ripe for development—when the smaller bones, the veins and tissues, should be pieced into the skeleton already constructed.

While fully acknowledging the valuable results of more recent African exploration, I submit that had geographers in general realized twenty years ago that it was time for generalization to give place to specialization—in other words, had recent exploration been directed more toward detailed research in specially selected areas, and less toward what is, after all, little more than the construction of glorified route maps—the world's knowledge of Africa would to-day be more complete and more accurate. It follows that to the traveler the former plan of campaign presents advantages which are denied the latter. An imposing journey from coast to coast is unquestionably of great personal and general interest. In passing rapidly from tribe to tribe and through various districts the most difficult to please will not complain of monotony or lack of interesting experience. Latitudinal positions may be fixed with accuracy, longitudes less definitely. A more or less sketchy account of the many peoples encountered may be entered in the diary, and a general idea of various local characteristics may be acquired; but these are more in the nature of first impressions, and, as the many conflicting ideas gleaned by different travelers in one and the same district tend to show, are not always quite reliable, and it is sometimes difficult to determine what to accept and what to discard.

Compare with work done on this principle the result of routes equally long which have been followed within a circumscribed area—a single country, so to speak. To begin with, the time during which the explorer has been in touch with one and the same tribe will be calculated in months instead of days. If he is experienced in native character and methods he will have gained the confidence of the people, he will have picked scores of brains on every subject on which he is in search of knowledge. From the outset he will have been learning facts and unlearning fiction. Having based his plans on hearsay

information he will have visited places of special interest, will have so arranged his routes as to enable him to fix cardinal points, to enter in detail the courses of important rivers, their sources and those of many of their tributaries. The larger affluents will have been crossed and recrossed at such intervals as will have enabled him to determine their mean direction. The boundaries of tribes and subtribes will have been similarly treated, and the many crossings of routes and independent connections with the base will have supplied checks and counter-checks of the greatest value. The result should be a map which will stand the test of time. In addition to this, even if the explorer is not an all-round specialist he will have collected as much data as will supply food for thought to the ethnologist, the naturalist, the botanist, and the geologist, and I venture to think he will, on his return home, be struck with the meagerness of the knowledge acquired during his journeys to and fro as compared with what he has learned in the objective country.

To efficiency in this case must be added economy, for once arrived at the base there is no longer need to carry about more supplies than are required for the few months or weeks during which each subsidiary expedition is at work. Thus, if the same caravan used for the conveyance of supplies from the coast or railway terminus is indispensable for the return journey, it can be split up into as many small caravans as there are officers in the expedition, and these can work separately along predetermined routes. If other means for the return journey are available, the bulk of the porters may be returned to their homes, and the local native—usually a much cheaper article—may be employed as necessity demands.

In conclusion, I would respectfully venture to remind the representatives of the many geographical societies assembled here in congress that the choice of method in this direction is largely in their hands. The would-be explorer will very naturally prefer to proceed on popular lines and will look for advice to those scientific experts in whose hands his work will ultimately be placed. If the geographical societies of Europe and America prefer to popularize the system recommended in this paper, the future explorer will more often work on those lines; if otherwise, reform in this direction will be less rapid.

THE FIRST AMERICAN ARCTIC EXPEDITION

By H. G. BRYANT, Philadelphia, Pa.

[Abstract.]

Mr. Bryant spoke of the discovery among the papers of the Historical Society of Philadelphia of certain documents describing an expedition sent to the Arctic in 1752. This expedition was sent in the schooner *Argon*, dispatched by the merchants of Philadelphia to explore the Northwest Passage. The schooner met with many obstacles and mishaps on the Labrador coast 300 miles north of the Straits of Belle Isle, and was obliged to turn back.

A COMPARATIVE VIEW OF THE ARCTIC AND ANTARCTIC

By FREDERICK A. COOK, M. D., Brooklyn, N. Y.

The two polar areas do not so greatly resemble each other as one would expect. From almost every point of view there is a wide difference. The land presents different topographical aspects; the ice, with a similar origin, follows different laws; the life of one region bears very little resemblance to that of the other; and the weather conditions are as different as they can be and remain frigid. The chief cause of this contrast between the Arctic and the Antarctic is the distribution of land and water. The Arctic land area is nearly continuous with the continental masses of the northern hemisphere, inclosing a landlocked sea, while the Antarctic is far removed from warmer continents, and is girdled by the boundless sweep of the great southern oceans. The north pole is in the center of an imprisoned sea of ice; the south pole is on a high ice-sheeted land, surrounded by a drifting pack, free to move as it will. These differences in topographical arrangement are the principal causes of the great dissimilarity between the two frigid zones.

For the purposes of this paper and for the needs of polar students I am going to offer the following division of the two polar areas into quadrants, the names used being based mostly on the largest land projection toward each quadrant:

Beginning with the longitude of Greenwich and following the sun I would name the first Arctic division the Greenland quadrant; the second, the Alaskan quadrant; the third, the Siberian quadrant; and the fourth, the European or possibly the Norse quadrant.

In the Antarctic, beginning again at the longitude of Greenwich and proceeding westward, the names naturally descriptive of the quadrants are the American quadrant, the Pacific quadrant, the Australian quadrant, and the African quadrant.

With this system of polar division, when we speak of the Greenland quadrant, or the Australian quadrant, there is an immediate sense of accurate location without further description.

The greatest contrast is noted when the physical characters of the two frigid land areas are compared. The Arctic contains a landlocked sea; the Antarctic embraces a sea-girdled land. The north

circumpolar area is land; the south is surrounded by water. To the north there is a land continuity; the south is isolated by wide water expanses. This peculiar arrangement has its greatest effect upon the life of the regions, but it also affects very materially the weather and the appearance of the land. The arctic explorer, as he crosses the circle in summer, sees very few signs of a frigid region. The climate is moderate, the land is covered by a hardy verdure, where animals graze and men hunt. Ice is only occasionally visible. To this condition the Antarctic offers a bleak contrast. On passing the green, tree-covered rocks of Cape Horn, the traveler almost at once plunges into the depths of polar frost and desolation. Long before the polar circle is reached he finds the lands buried beneath a sea of ice, which extends everywhere to the sea shore, leaving only an occasional nook where a few mosses and lichens struggle for subsistence. He finds no trees, almost no vegetation, no large animals, and no human life. The continuous glacial walls almost everywhere forbid a landing, and only an occasional bare rock, too steep for snow to rest upon, is visible. Along the Arctic coast, even to the farthest reaches, there is a fringe of land that is free from ice during the summer; the glacial output is by tongues descending through deep verdure-clad gorges, where poppies and saxifrage bloom, and where the reindeer and musk ox find food. In the far south there is no such life-sustaining coastal fringe; there is ice to the sea, almost perpetual storm—seemingly eternal death and desolation.

The Arctic Ocean occupies an area somewhat larger than the probable extent of the combined spread of the Antarctic lands—approximately 4 million square miles. The continents of the northern hemisphere are so grouped around it that the physical environment is similar to that of a great lake with well-defined inlets and outlets. The volume of fresh water poured into the Arctic basin by the many large rivers must be considerable, but the glacial bodies, except along the coast of Greenland, are very insignificant compared to the great masses of the southern ice cap. The sea finds inlets through Bering Strait and along the Norwegian coast with a feeble current which is lost soon after it enters the ice zone. Owing to the almost continuous circumpolar land area, direct contributary precipitation is small, but the rivers bring to the Arctic Ocean the precipitation of a very extensive area. The outlet is rather narrowly limited to the shores of Greenland, mostly along the east coast. Much has been said of a polar current, but up to the present we have no evidence of a transpolar flow of water. Ice is very sensitive to wind force and we now know that the prevailing winds from the Siberian quadrant carry with them an ice drift toward Greenland. A similar effect was noticed by the Belgian expedition in the south polar region, but this ice drift should not be confused with a sea current.

The Antarctic Ocean is circumpolar in its sweep and has no definite northern limit. If we place the dividing line at the outer edge of drift ice, the area encompassed will be equal to one-half of the entire land surface of the globe. This enormous area of water is more or less homogeneous. There is no rule, so far as we know, affecting materially one part which does not also similarly affect all parts. The disturbing influence of land is in the midpolar basin. This peculiar freedom of movement and unlimited expanse exercises a powerful effect upon southern climate and ice conditions.

There are no known warm currents, either atmospheric or marine, directed toward the Antarctic to moderate circumscribed land areas in the manner in which the Gulf Stream tempers Norway and other lands of the Norse quadrant. The limitless seas which sweep around the Antarctic exert à great moderating influence upon the atmospheric temperature, but the interposition of a high land mass is a cause of the violent storms. The making and breaking of polar ice offers an interesting study in terrestrial physics. The problem, however, is too large to elaborate in this paper.

To the proper under standing of bipolar contrast it will be necessary to present some points of this curious ice chronology. While the eccentricity of the earth's axis is probably responsible for much of the polar frost, the ice accumulation is very largely dependent on physical conditions. The first differential impression which one gets of the southern pack is that the sea ice is lighter and the land ice is heavier than that of the Arctic. The actual thickness of both floe and berg ice, as one finds it in the moving pack of summer, is probably similar about both poles, but the southern floe covers a smaller area, while the berg is longer and wider. The greater freedom of movement explains the more broken pack, and the more extensive ice cap of the South affords larger bergs. The greatest possible contrast is to be noted in the making and breaking of the sea ice. In the Arctic Ocean the ice accumulates in winter and melts in summer, and recongeals again in winter only to break the next summer. The ice follows a law of development, waste, and repair somewhat similar to the tissue of animals. There is a kind of digestion, assimilation, and rebuilding - a system of natural equilibrium within the ice borders, for the amount of ice discharged compared to the total volume is very small. The Antarctic Ocean follows a different rule in its laws of expansion and dispersion. While a small amount of waste is noted within its borders the ice generally forms far south, drifts freely with the prevailing winds, and gradually presses northward along the line of least resistance. Behind, new ice forms in the open spaces and at the edge of the pack the drift ice is doing a ceaseless battle with the great warm swells of the southern seas. This rapid expansion and

drift make doubtful the possibilities of travel over the Antarctic for any considerable distance from the land.

The climatic conditions of the frigid zones are very different. Reasoning from rather insufficient data it is possible to form only broad general conclusions. Both zones present a marine climate, but the Arctic is disturbed very much by a complex system of continental influences. The Antarctic, on the other hand, is controlled by the sweep of the circumpolar seas. It is difficult to discuss the Arctic climate as a whole, because there is a great dissimilarity in various sections. The Alaskan and Spitzbergen climates are about as far apart as the distance which separates them. In the Antarctic there is no such local contrast. We must now remove the pole of greatest cold from Siberia to the Antarctic highlands; we must put down the Antarctic as the worst spot on earth in its effect upon animal comforts. It is not the low temperature which is most disagreeable; it is the force of the wind and the relative amount of humidity. Almost ceaseless cyclonic winds and the highest possible humidity with steady low temperatures are the characteristic features of Antarctic weather. With a sky but rarely clear, there results a gloomy color effect, and this with the maddening force and persistence of the wind presses human endurance to the verge of desperation. The Arctic is quite the reverse in its effects upon the senses. Here the color is bright and cheerful, and the general weather characteristics are stimulating. Most Arctic explorers, be their lot ever so hard, want to return; but I have not noticed in any of my comrades a great longing to get back into the Antarctic gloom. The general weather peculiarities of the Arctic are erratic winds and violent storms, separated by calms; winter temperatures somewhat similar to those of the South; but a warm summer air, favorable to a luxuriant fauna and flora.

The geographical distribution of animal life in the polar regions is clearly controlled by possible avenues of migration. In the North the life has been able to follow the retreat and advance of the continental ice, but in the South the ice has so completely covered the land that the fauna and flora have been forced into the sea. In the Arctic there survive some of the descendants of the former life along the old ice edge. The Eskimo, the musk ox, the reindeer, and the white bear have probably followed the recession of the crystal cloak of the great ice age, but these have no prototypes in the far South. The entire pre-Glacial life seems there to have been destroyed, and there remain to-day only a few cryptogams and dipteras which in all probability have been transplanted by large-winged birds. The aquatic life does not present so great a contrast. The deep-sea fauna is, as Doctor Ortmann has put it, "world wide;" but the surface life, though in a broad sense similar, presents some peculiarities. The temperate and torrid seas seem to offer an effective obstacle to migration. The penguin, which

is the most striking Antarctic adaption, should thrive equally well along the edge of the arctic ice, but it has never crossed the equator. The same thing could be said of the petrel, the albatross, the seals, and the whales. Under somewhat similar conditions the marine life about the polar areas has developed peculiarities which are not yet explained. In the domain of aquatic biology there is an unexplored field, leading up to the origin of species, which promises many interesting results. Why have the seals developed along different lines? Why has there been no animal in the South similar to the walrus or the narwhal? These and many other questions suggest the urgent need of further investigation along the line of international cooperation as advocated by Arctowski. Whether we accept or reject the theory of the influence of the eccentricity of the earth's axis, the key to the mysteries of contrast between the polar areas is to be found among the resultant physical forces due to the unequal distribution of land and water.

The conditions which favor the making, accumulation, and disintegration of polar ice originate mostly outside of the Polar Circle. The amount of atmospheric saturation is dependent upon the open sea area bordering on the frigid zones. The precipitation is facilitated by high land; the force and direction of wind are controlled by high or low pressure areas, which areas in turn are made possible by the facilities offered for heating or cooling localized volumes of air. The process of disintegration is helped by freedom of ice movement and by high summer temperature. The bipolar ice differentiation is due mostly to varying applications of these principles.

In the North the great attraction to explorers has been the glory of attaining the pole. In the South the aim has been to determine the limits of the hypothetical continent. Both objects remain unattained, but the combined efforts have given us a priceless fund of useful knowledge. The fascination of the north-polar dash will increase rather than diminish, and with it will grow a similar enthusiasm to reach the South Pole. A forced march to the boreal center, though quickly made and under difficulties so great as to prevent detailed investigation, would nevertheless give us a valuable record of the physical environment of the mysterious Arctic basin. Such a record could be supplemented by subsequent studies of circumscribed areas, which when combined with our present information, would give us a good picture of the Arctic as a whole. Our record of the Antartic is singularly incomplete and uncomprehensive. Several inland expeditions are needed to acquaint us with the great overland sea of ice. The present links in our incomplete chain of polar knowledge should be joined together by expeditions carried into the boreal sea and across the austral highlands, to or beyond the geographical poles. The explorer has next to plan a journey to both the North and the South poles.

THE VOYAGE OF THE BELGICA

By FREDERICK A. COOK, M. D., of Brooklyn, N. Y.

[Abstract.]

The voyage of the *Belgica* fills a unique position in the annals of antarctic exploration. Three important results make this expedition notable for all time: Its records give the first consecutive series of observations during the yearly cycle; the drift made possible the first tangible study of the making and breaking of the pack ice, with its fauna and its peculiar environment; the work as a whole gives the first purely human story of life through the winter.

Nineteen men intrusted their lives to the little *Belgica*, and with her attacked, in 1898, the previously impenetrable ice barriers south of Cape Horn. They discovered a new and beautiful highway, in size comparable to the Strait of Magellan, and through this pushed into a new world of ice, discovering many islands and several hundred miles of land. After passing this land the explorers entered an equally unknown sea and were imprisoned in a part of the great restless pack of limitless ice which guards the South Pole. Here for a year they were stranded on a piece of ice, were the football of fate, thrown to and fro with the wind over a mysterious ocean. In this aimless drift the pioneers made a continuous study of the life and conditions of this icy region of the globe. They passed, for the first time in the history of man, through the experiences of an antarctic winter night, preceded and followed by a series of the most dreadful storms which has ever been recorded.

The *Belgica* contained at this time the only human life within the antarctic and subantarctic regions—an area equal to the combined spread of Europe and Asia. If the bark had been crushed, not one would have ever returned to the warmer zones. This uncertainty of the future was ever before the adventurers. Finally, when the long days of midnight suns were fading, and the gloom of another long winter blackness was spreading over the white splendor of summer, they sought to obtain relief by their own efforts. It was proposed to cut a canal to release the *Belgica*, and to this mission the entire personnel devoted every thought and muscular effort, with the gratifying result that on March 14, 1899, the ship left the ensnaring pack ice, freed by the almost superhuman efforts of the men who first invaded the sleeping solitude of the long antarctic night.

COLOR IN THE NORTH AND SOUTH POLAR REGIONS

By FRANK WILBERT STOKES, New York City.

The barren, savage polar regions, with their intense cold, terrific storms, and long polar night, with the absence of trees and only a sprinkling of verdure in the North, have always been looked upon as entirely devoid of color—only black and white; but just the reverse is the truth. In polar solitudes, where man comes closer to the Creator than in any other region, there is unveiled to the eyes of the few who have ventured thither the richest color that Nature produces. I believe that the principal element in the fascination of these regions is color, for it has impressed itself powerfully upon all polar explorers.

In the far North the land forms repeat themselves, as they do also in the far South; but the wonderful kaleidoscope of color changes and light and shade that passes before one's vision is more varied than that of the Temperate or Tropic zones, whose dominant color is green. In the latter the land is more or less covered with vegetation, which has varied shades of green, but is always green, except in autumn, and the appearance is monotonous compared to that of high latitudes, where the air is preternaturally clear and the rocks and earth are seen in their myriad pristine colors; where the rich-colored mosses, the lichens, and the grass and flowers are uncovered for miles in the summer time. Then the snow reflects all the richest and subtlest colors from the ever-changing skies more sensitively than either water or verdured landscape. The wonderful colors of the ice itself, the increased brilliancy and colors of the stars, the beautiful parhelia, the majestic forms of the great ice mountains, and the ethereal splendors of the polar auroras—all together make it a region of color par excellence.

The conformation of the land in the far North is less hidden than in the far South, as the latter is in an earlier stage of the ice age, and is therefore covered by greater quantities of ice, so that the contours of the antarctic lands seem rounded in comparison with the more jagged aspect of the northlands.

The polar ice has its own intrinsic colors. I have made many sketches from nature in both the North and South polar regions, under all conditions of weather, and I always found the rich colors in the ice. These colors appear in fissures and wherever the light penetrates the ice. The polar ice is translucent and not transparent. It is very much like alabaster; occasionally one may see a small piece of transparent or "glare ice." The colors of the arctic ice are varied shades of cobalt and ultramarine blue and malachite greens; the antarctic ice colors are principally varied malachite greens and warm yellowish greens.

A peculiarity of the antarctic region is the appearance, at rare intervals, of icebergs which present a solid mass of rich, deep cobalt blue. These bergs are generally small, but on one occasion we saw a solid-blue berg of huge proportions, and it was such a novelty that all on board the little ship *Antarctic* stopped for a moment their various duties to gaze at the beautiful ice monster with silent admiration. An iceberg such as this has never been seen north of the Arctic Circle. This large berg and a number of small blue bergs were sighted off Joinville Land, February, 1902.

The color of polar ice is produced by the enormous pressure to which it is subjected in the interior of the polar continents, where it is thousands of feet in thickness. This pressure forms a peculiar crystal which polarizes the light and produces color. However, the yellow-pea-green color, seen frequently at the bases of icebergs and floes in the Antarctic, is caused by animalculæ, and in places I have observed a deep bottle-green.

The auroras of the North differ greatly in form and color from those of the South. I have never witnessed the latter, but from what I can learn they are much less vividly colored than the aurora borealis, and have generally the forms of rays and arches. The aurora borealis is the most beautifully colored creation that man has beheld. The forms richest in color are the striped arcs, crowns, or glories, and especially the draperies and ribbon aurora. The colors have been said to be less pure when the air is free from fog, but our experience has been, like that of some others, just the reverse. The auroral light seldom exceeds in intensity the light of the moon in its first quarter. Although the colors most frequently seen are pale yellows, blues, and reds, yet brilliant greens, salmons, crimsons, rose, orange, deep blues, and violets often appear. The forms of the aurora are myriad in variety, gigantic columns, serpents, gods, goddesses, etc., succeeding each other with lightning-like rapidity. In texture it resembles an infinitesimally fine-spun spider's web of vast proportions, through which the stars shine clear and bright.

Contrary to generally received opinions, the long arctic night is full of beautiful color harmonies, and is not so grewsome as it has been depicted. At the far southern horizon a deep-orange glow, the reflected light of the hidden sun, can be seen, succeeded by orange-yellow, greenish yellow, greenish blue, fading into the deep ultramarine blue of the zenith. The arctic colors are characterized chiefly by their rich splendor and brilliant intensity. There is nothing more opulent and regal than the colors of the midnight sun and the awesome beauty of the aurora.

The arctic night approaches gradually by a long series of very subtle twilight-color harmonies, ravishing to the senses, while the long summer day returns in the same fashion. In the Antarctic there is the same fading of day into night and night into day. In latitude 77° 43′ north, where I spent the winter of 1893–94, the twilight series lasted, roughly speaking, from the middle of September to about the middle of November, and from the middle of February to the middle of April. The interim was the darkest part of the long night, but even this was enlivened, when the weather was clear, by the sun's reflection in the South, the wonderful clearness of the atmosphere, and the unrivaled brilliance of the moon and stars, while the long, deep-blue, purpled shadows across the lilac-golden surface of the bay ice were rendered more beautiful by their penumbra, which had the colors of the rainbow. The parhelia are also full of these colors. In the Arctic the color of the water is a gray green, but, of course, generally what the sky is above it. In the Antarctic the color of the sea, when not affected by reflection, is also a gray green, colder and more blackish in tone than in the North. I refer to the waters of Davis Strait, Baffin Bay, and Inglefield Gulf in the North, and to Bransfield and the Gerlache Straits, Erebus and Terror Gulf, and Weddel Sea in the South. I have, of course, seen these seas as blue as the Mediterranean, with a truly Mediterranean sky above. However, the waters in the Antartic were, as a rule, reflections of the gray, dun-brown, deep-gray, black, blue, and cold gray of the ever present pall of funereal cloud masses that rolled overhead threateningly with the whistling gales.

It is certainly worth while for an expedition to bring back the color and atmospheric aspects of the polar regions; for color plays a most important part in the characteristics of any particular region, and must strongly affect its inhabitants, whether man or animal.

The wonderful beauty of nature was created for a wise purpose, and art, the translator of one of its most predominant aspects to mankind, has a most important mission. I am fully convinced that art is not a luxury, but a necessity. The best tonic for the jaded mind and body is the beauty and grandeur of nature. Nature is the inexhaustible

source of inspiration for man in every walk of life. As the scientist teaches man to see new forces and to use them, so the artist leads man to see the beauty in nature. Because all men have eyes they believe they can see, and they do, but only partially and ignorantly. It does not follow because a man has looked at a scene that he has seen its color beauty truly. In general it may be said that the color of the Arctic is full of gladsomeness mingled with deep, dramatic touches of gloom, while the Antarctic is pervaded by wild, somber, sinister color, now and then relieved by a burst of gorgeous beauty.

GEOGRAPHICAL PROGRESS IN THE DUTCH EAST INDIES, 1883–1903

By Dr. C. M. KAN, Amsterdam, Holland

Few parts of the globe present for solution more scientific problems than the Dutch East Indies in the fields of geology and biology, meteorology and magnetism, anthropology and linguistics, archeology and religion, economy and statistics.[a] The literature of few parts of the globe lies so dispersed and covers so long a period. To indicate the progress after 1883, the condition of geographical research in that year can be expressed briefly thus: Since the fall of the Dutch Oriental Indian Company the colonies, or rather the possessions of the State of the Netherlands, have been transformed from pure mercantile into agricultural and mining colonies. Up to the decade 1850–1860, during the wars and the extension of the Dutch Government to the interior parts of the isles, they were traveled and possibly studied by political agents, military and civil functionaries, missionaries, and some better-prepared naturalists. The progress made since that time by the institution of the board of mines, the meteorological and magnetic observatory at Batavia, the topographical and hydrographic service, the botanical garden at Buitenzorg, all by the Government; the foundation of a very large number of societies and periodicals, both in the mother country and the colonies, by individuals, promoting research and scientific expeditions—that progress is fully shown by the catalogue of the first colonial exhibition at Amsterdam (1883), composed under the supervision of the eminent indologist, Prof. P. J. Veth, at Leiden, by different specialists in the extensive field of indology.[b]

[a] Veth, De toevoeging der talen en letterkunde van Nederlandsch-Indië aan de vakken van hoogir onderwys, Leiden, 1877, pp. 6–8, where the problems in the field of physical, historical, and social sciences are enumerated.

[b] Catalogue de la section des colonies néerlandaises à l'exposition coloniale internationale, Leiden, 1883. The status quo of colonial science in the Netherlands in 1883 can be studied also from the Conferences scientifiques held at the colonial congress of that year (Leiden, 1884) and the Rapports sur les congrès, par M. D. Josephus Jitta (Questions commerciales, industrielles et coloniales), Amsterdam, 1884. Since that year the progress for shorter periods is reviewed in the Revue coloniale internationale, Amsterdam, 1885–1887; the Journal of the Dutch Geographical Society, 1887–1897, and up to 1900 in the Guide à l'exposition universelle de Paris (section Indes néerlandaises).

Yet the latest period shows much important progress, viz: The first steps in the field of scientific maritime geography; more detailed study of a smaller terrane by well-prepared and well-equipped naturalists; geographical research in the eastern parts of the archipelago (Little Sunda Isles and the Moluccas); the study of ethnology and ethnography after the principles of modern science, and a more extensive diffusion of the results obtained by these inquries, as will be better shown by treating the details.

That maritime geography and oceânography—the study of the deep sea (very different from the hydrography of the coasts)—before 1883 was neglected is proved by the complaints of geographers, geologists, and biologists as to the want of data for the study of salinity, currents, tides, temperature, and depth of the sea, with its fauna.[a] Since that year colored charts showing the depths of the different basins of the archipelago have been prepared. Doctor Schott has contributed to the knowledge of salinity and the division of the sea surface in that regard. The results of studies of currents, tides, and temperature, at the surface and in the depths, are collected on the charts of Doctor Krümmel and in the Atlas of Winds and Weather, by Doctor van der Stok, Batavia, 1894. A new nautical guide (Zeemans gids voor den Oost-Indischen Archipel) gives an excellent text to the new sea charts. The maritime expedition of Prof. M. Weber has given many naw data on the relations, the depth, temperature, soil, and fauna of the basins (Banda, Savoe, Celebes Sea, etc.), their connection with the Indian and Pacific oceans, the conditions of life for the fauna and flora of those basins, with the temperature and other special biological conditions of the archipelago.[b]

Professor Weber's work, done since 1883, has covered a wide field. From the more detailed quite careful survey of the western part of the archipelago and Banka Strait he turned since 1890 to a more flying survey of the eastern part—the large number of isles between Celebes and New Guinea. The better sea officers, educated by eminent astronomers (Oudemans, van de Lande and Bakhuyzen), connected more rationally the topographical and astronomical surveys with the hydrographical. The hydrographic service, transferred from Batavia to The Hague and connected with the ministry of marine, supervised and accelerated the publication of sea charts. A special

[a] See Findlay, Directory for the navigation of the Indian Archipelago, edition 1889; Sawyer, Sailing direction of the Indian Ocean; A. Martin, Text-book of ocean meteorology, 1886 and 1887; Deutsche Seewarte, Atlas vom Indischen Ocean, 1891; Blink, Wind und Meeresströmungen im Gebiet der Kleinen Sunda Inseln, Stuttgart, 1887; Kan, Net maritieme onderzoek van der Oost-Indischen Archipel, Tijdschr. Aardr. Gen., 1895.

[b] See Schott, Wissenschaftliche Ergebnisse einer Forschungsrise zur See Peterm. Mitt., Ergänzhft., 109; Siboga, la partie II, 1899–1900, Introduction et description de l expédition par Max Weber, avec des figures et cartes; Leide, Z. J., Zeemansgids voor den Indischen Archipel, edited by the Marine Ministerieum, I–III, 1899–1904, and Naber, Zeemanshandboek, Deele I, II, 1900–1901.

board has increased the number and reduced the price of these charts and revises them with care for their exactness.[a]

As better sea charts were required by Dutch and foreign navigators and merchants, still more urgently were detailed and exact land charts demanded, long before 1883, by the Government and by individuals, for works of war and peace—the administration of the newly gained colonies, the new plantations, roads and railways, works of irrigation, geological and mineralogical researches. Yet the progress in the topographical survey and the land charts since 1883 is easily shown. The triangulation and a greater part of the topographical survey of the large island of Sumatra fell between the years 1883 and 1900, also of the western division of Borneo (1886–1895), and the construction of better charts of southern Celebes, eastern Borneo, the Moluccas, Banca and Biliton, Bali, Lombok, and Sumba. The topographic bureau at Batavia, during that time, in connection with the topographical service at The Hague, corrected largely the technical worth of the charts, their projection, and their usefulness not only for the soldier, but also for the geologist, the scientific traveler, the agriculturist, and the engineer. Even the terranes not topographically surveyed—New Guinea, Toba Lake, etc.—are mapped more carefully, the cartographer consulting critically all the data given by soldiers, functionaries, mariners, engineers, and scientific explorers. A very useful statement of the size and surface of the innumerable isles of the archipelago, planimetrically measured, is given,[b] while unexplored spots on the charts were in 1883, and are even now, not rare.

How these spots have diminished since that year will be shown in this short account by enumerating the principal explorations. To the interior of Atschin (land of Gajós and Alas) military expeditions penetrated. Their surveys and the information gained from the aborigines by himself, Dr. Snouck Hurgronje has collected and exhibited in his work and on a chart of that land; the highlands around the lake of Toba and the lake itself, after numerous travels of explorers, military expeditions, and geological and topographical surveys, find a place on this chart. In late years, in the better surveyed part of Sumatra, the expedition of the engineer Yzerman (1895) crossing the island from the Ombilin coal fields and Kurantan to the Kampar and Siak rivers, contributed largely to the knowledge of those waterways and the ethnography and botany of equatorial Sumatra. The wars in Djambi and Korintji, since 1902, opened the

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[a] Lists of new and revised sea charts are given in the Regeerings Almanak, edited by the colonial government of the Dutch East Indies, and in the journals of the Dutch Geographical Society of late years.

[b] Bureau topographique à Batavia: Notice sur les cartes, livres et objets composés et recueillis par le Service topographique, Batavia, 1890; and Encyclopædie van Nederlandsch-Indië, under the word "kaartbeschryving."

countries along the Batang Hari (upper Djambi) and the valley of Vorintji, closed before. Passing Java, in 1883 already trigonometrically surveyed, for the isle of Borneo we have only to remember the names of Büttikofer, Hallier, Molengraaff, and Nieuwenhuis, who explored the biology, geology, and ethnology of a large district in the interior of the largest island and also its unknown orographical structure. Very recently the northern and southern halves of Celebes were explored by Professors Weber and Wichmann; both the halves and the interior by the Doctors Sarasin. For the exploration of the eastern archipelago (the great east), the Government geographical and other scientific societies strove, as is said above, to fill up the large gaps in our knowledge, the Dutch Royal Geographical Society at Amsterdam selecting as their field Flores, Sumba, Timor, and the Key group, explored by van der Broek, Ten Kate, Wichmann, and Planten; the Royal Institute, the geography and ethnology of the archipelago, that of the Moluccas to be explored by Professor Martin; the Society for the Physical Exploration of the East Indies selecting the western half of New Guinea for exploration by Professor Wichmann. Several other isles of that great east were studied by eminent explorers—for instance, the isles of Bali and Lombok, by Liefrinck; the Aroe group, the southeastern and southwestern isles, by van Hoevell; Ambon and the isles east of Celebes, by de Clercq; Halmaheira, by Campen. The results of these explorations have all been published.[a]

[a] As to Sumatra see Snouck Hurgronje, Atjeh en de Atjehers, Batavia, 1894; Jacobs, Het familie en Kampongleden op Groot-Atjeh, Leiden, 1894; Het Gajoland en zyne bewoners, by Snouck Hurgronje, with a chart of Gajo and Alas lands, Batavia, 1903. A review of the explorations around the Toba See and in the Batta lands is given by C. M. Pleyte in the Journal of the Dutch Geographical Society, 1895. The results of all newer explorations in the Atjeh and Batak lands are indicated on the newest chart of the Atlas of Stemfoort and Ten Siethoff, North Sumatra, 1904. The results of the Yzerman expedition are published in the work Dwarsdoor Sumatra, Batavia, 1895.

We pass Java as well known before 1883, since the island was geologically explored and described by Verbeek and Fennema (Geologische Beschryving van Java en Madura, with atlas of 26 sheets, 1 : 200,000). A new edition of Veth's eminent work, Java, geographisch, ethnologisch, historisch, appears, edited by Snelleman and Niermeyer. For the detailed literature of the isle and its residencies see Encyclopædie van Nederlandsch-Indië, under "Java" and the different residencies.

The newest literature of Borneo gives the first place to the works of Professors Nieuwenhuis, Molengraaf, and Enthoven, respectively, in Central Borneo, Leiden, 1901; Geologisch Verkenningstochten in Centraal-Borneo, with atlas, Leiden and Amsterdam, 1900; and Bijdragen tot de Geographie van Borneo's western Afdeeling, Deel II, Leiden, 1903. For the literature of the various parts of the large island see Borneo in the "Encyclopædie van Nederlandsch-Indië."

For the northern half of Celebes the explorations of the engineer Van Schelle, Professor Wichmann, and Professor Buckling are to be found, respectively, in the Jaarboek van het Mijnwezen, 1889, pp. 3, 39, and II, p. 133; and Petermann's Mitteilungen, 1893, pp. 225, 253, 279; id., 1899, XII. Baron van Hoëvelt published a detailed geographical description in the Journal of the Dutch Geographical Society, 1891-1893. For the southern half the best and newest publication is that of Professor Wichmann in the latter journal, 1899 and 1890. For the explorations of the Doctors Sarasin they will themselves sum up the results, and for the other parts of the island we must refer to the article "Celebes" in the Encyclopædie van Nederlandsch-Indië, where to the description is added a detailed list of the literature.

For the Moluccas as a whole see Onze geographische Kennis der Molukke, Journal

For the geology these results have been, since 1883, four times discussed in late years (1895–1902)—by Doctors van Cappelle and Verbeek; by Professor Martin; by Professor Koto and Doctor Verbeek, after his geological exploration of the Moluccas, and by Professor Suess. The first named give the review of different formations and rocks composing the various isles—Archean (schiefer and granite), forming the basis, the skeleton of nearly all the isles; Paleozoic, more rarely, as sandstone and diabase, indicated on Sumatra, Timor, Robi; Mesozoic (Trias, Jura, Cretaceous formations), for the greater part of the isles, determined only after 1890; Tertiary and recent formations, with andesite and volcanoes, coral reefs, and the diluvium or alluvium forming the hills and flats around the skeleton. Professor Martin discusses the changes in relief caused by microseismic and macroseismic motions of the land, demonstrated by the elevation of coral reefs and strands several hundred meters above the sea.

As Professor Martin studied the elements and history, so Professor Koto studied the actual structure of the archipelago, basing his results on the compilation of Suess (1885) and on his own observations. Dividing the archipelago into the exterior arc of volcanic and the nonvolcanic isles, as before him Wichmann and others had done, he points out the agreement of the three zones near New Guinea with the Antilles by comparison with the Riu-Kiu group; for the interior isles (Borneo, Celebes, Halmahera), "old geologic blocks and other relics of southeast Asia, left as giants among the ruins of the long-lost land," he tells the history of their exploration and their geologic relation to the exterior of the Malayan arc or their affinity with the Philippines. Doctor Verbeek, making the Moluccas, long time neglected, the object of his special and profound studies, for that part of the archipelago obtained special results—that the form and size of the isles in that part are the consequence of the sinking of the land, therefore not of volcanic action only (there are about 30 volcanoes, 11 active, on 912,000 square kilometers), or, elsewhere, of accretion and elevation of the isles; that the volcanic isles are to be distinguished into older (Mesozoic and Tertiary period) and younger (Quaternary), and that to the neo-volcanic isles, as regards their size, must

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of the Dutch Geographical Society, n. s., IV, p. 560; Martin, Reisen in den Molukken, Leiden, 1894; Riedel, De sluik en kroesharige Rassen tusschen Selebes en Papua, Haag, 1886. For the principal groups of isles, van Hoëvell, De Aroeeilande, Tijdschr. Bat. Gen., XXXIII, p. 57; for the Key group, Planten and Wertheim, Verslag van de Waarnemingen en Onderzoekingen, 1889–90, with map and ethnographic atlas, Leiden, 1893; for Holmaheira (Jilolo), Campen, Bijdragen van het Instituut voor Taal-, Land- en Volkenkunde, 1885–88, and Kükenthal, Forschungsreise in den Molukken, Frankfurt, 1896; for New Guinea (western half), Haga, Nederlandsch New Guinea, Batavia, 1884, and Kan, Geographische Untersuchungen in der Westhälfte von New Guinea, in report of Sixth International Geographical Congress, London, 1895.

For the Little Sunda Isles (Bali, Lombok, Flores, etc.) and the Timor group the literature is given in the Encyclopædie van Nederlandsch-Indië and in the Encyclopedia Britannica (supplement).

Dresden, and by Professor Bastian at Berlin. The eminent studies in the field of ethnography initiated by Professor Wilken were continued by his scholar, C. M. Pleyte, and by Doctor Steinmetz. In the International Archiv of Doctor Schmeltz, the director of the Ethnographic Museum at Leiden, and in the Bijdragen of the Royal Institute for Ethnography at The Hague, as well as in the publications of the missionary societies and in the Journal of the Dutch Geographical Society, were described more especially the customs, languages, history, and ethnographic condition of all indigenous peoples and tribes visited since 1883. Not only the indigenous populations, but also the foreigners had their turn—the Arabs and Islam; the Chinese, their Kongsis and religion; the Europeans (Dutch), their means of subsistence, prosperity or poverty, education, marriage, and social condition. In closing it may be remarked that, with the more careful government of the state and the increasing interest of the Dutch nation in their possessions and colonies, the statistical data about the indigenous and foreign inhabitants were still more needed, and were procured, viz, about the density of population, the agriculture, breeding of cattle, fishery, industry, navigation, commerce, and means of transport. The Government, societies, and individuals strove to collect this data and to publish it in visible form—by tables, diagrams, and charts.[a]

What is said here of this statistical data can be extended to the diffusion of the knowledge gained by so many explorers in different fields. The Government improved the form of the official publications, "Koloniale Verslagen," "Regeerings Almanak," "Statistick van Handel en Scheepvaart," etc., or supported those of societies and individuals by large subsidies. New societies and journals augmented the number of those which existed in 1883; a new Repertorium and the "Encyclopædie van Nederlandsch-Indië" facilitated the study of details and the review of the dispersed literature; different memorials in the year 1898, as Queen Wilhelmina commenced her reign, described the moral and material condition of the colonies during recent years; manuals, atlases, and charts, as well as popular descriptions, pictures, and illustrations promoted the study of colonial geog-

[a] In addition to Professor Zaayer's article, Anthropologie van Nederlandsch-Indië (Catalogue Expos. 1883, I, p. 448), reference can be made, in the field of anthropology, only to Dr. B. Hagen's "Anthropologische Studien aus Insulinde, mit Messungen, Tabellen und Tafeln" (Verh. der K. Akad. v. Wet., Nat. Afd., 1890–1892); Doctor Ten Kate's Ein en Ander over anthropologische Problemen in Insulinde en Polynesië (Veth's Feestbundel, Leiden, 1894, p. 233), and Contributions à l'anthropologie de quelques peuples d'Océanie (L'Anthropologie, 1893, IV, p. 279). A manual for the Vergelijkende Volkenkunde van Nederlandsche-Indië, after the lectures and notices of Professor Wilken was published by Pleyte, Leiden, 1893. The most apt publication for the statistical data is Jaarcijfers voor de Kolonie bewerkt door het Centraal Bureau voor de Statistiek, derived from all the Government publications (specially named), the departments and boards of commerce, navigation, instruction, mining, and railways.

raphy throughout the nation, and raised the level of geographical instruction about the colonies in primary and royal schools, the gymnasia, and the universities.[a]

[a] The principal works are those of the Maatschappij tot het natuurkundig Onderzoek der Nederlandsche Kolonien, with Maandberichten concerning the explorations in New Guinea; those of Nieuwenhuis, Weber, and Molengraaff, above named; the organ of the civil functionaries (Tijdschrift van het binnenlandsch Bestuur); different organs of societies for promoting agriculture ("Cultuurgids," "Archief voor Java Sinkerindustrie," Indische Landbouwcourant," etc.); the engineers' organ ("Ingenieur"), etc. The best Repertorium, in addition to the Aardrijkskundig en statistich Woordenboek van Nederlandsch-Indië, 1865, is that of Hartmann (I, 1865–1894; II, 1894–1900, 's Hage, 1901). The "Encyclopædie van Nederlandsch-Indië," by the late Professor Van der Lith, succeeded by J. F. Snelleman, is advanced to the letter T. The memorials referred to are Nederlandsch-Indië onder het Regentschap van Koningin Emma, 1890–1898; Historisch Gedenkboek, 1848–1898; Les Pays-Bas, edited by journalists, 1898. The best manuals are Hollander, Land en Volkenkunde, new edition, 1895; Schuiling, Nederland onder de Tropen, and the Toelichting given to the chart of the Dutch Indies, edited by the journal Nieuws van den Dag, 1890.

FIRST EXPLORATION OF HOH LUMBA AND SOSBON GLACIERS—TWO RECORD ASCENTS IN THE HIMALAYAS

By FANNY BULLOCK WORKMAN, London, England

The bases of our last two expeditions in Baltistan, northwest Himalayas, are reached in 23 marches from Srinagar, the capital of Kashmir. This region, the glaciers of which were first explored by us, lies between 74° 55′ and 75° 45′ east longitude and 35° 45′ and 36° north latitude. From Skardu, the chief village of Baltistan, a march northeastward brings one to the Shigar Valley, which is traversed in 20 miles to its junction by the Bralboh and Basha rivers. Here the Bralboh Valley is followed for 14 miles to the small village of Hoh, which lies 9,400 feet above the junction of the Hoh and Bralboh rivers. Here on July 19, 1903, our caravan, composed partly of transport coolies engaged previously at Skardu, was reinforced by Hoh coolies. Added to these were camp servants and a Hoh lumbardar, or chief, making a total of 60 men. Accompanying Doctor Workman and myself were Mr. B. Hewitt, topographer, and the noted Italian guides, Joseph Petigax and Cyprien Savoie, of Lourmayeur, and El Petigax, porter. The narrow Hoh ravine, or nala, as ravines are called in these parts, runs north, and is ascended along the precipitous cliffs of nude mountains. It is filled by old glacial débris several hundred feet deep, containing bowlders of all sizes, some extremely large. At the bottom of this desolate ravine runs the Hoh River, a rushing, khaki-colored, glacial stream, which cuts its way often at a great depth. Beyond this an enormous winter avalanche, strewn with black detritus, reaching from one side of the nala to the other and completely covering the river, was crossed. No vegetation except the hardy aromatic burtse plant and a few scattered rose bushes is met with until Pirnar Tapsa, a small grazing ground, is reached, about 4 miles up. This is fairly well covered with birches and cedars. Two miles farther is Nangma Tapsa, a similar grazing spot, at 11,595 feet, where we camped. Here are the tapsa and snout of the Hoh Glacier. Sportsmen sometimes come

here in search of ibex, which are found on the mountain flanks bordering the lower part of the glacier.

Colonel Godwin-Austin saw the glacier from a distance when surveying for the government of India in 1862, but our party was the first to ascend it. Its general direction from Nangma Tapsa is northwest. Its length from the snout to its source under the great col is 11 miles, its greatest width 0.6 mile, and its width at upper end below the source 0.4 mile. It seems to have retreated somewhat rapidly of late years. Above Nangma Tapsa is an extensive old moraine strewn with large blocks and covered with trees. The farthest point of this is about a mile in front of the present glacier. Then comes a marked division where the moraine matter is much smaller; there are no large blocks and vegetation is scarce. At this point near the oldest part of the moraine is some small scrub, but this ceases about one-half of a mile from the glacier and the moraine has a generally new appearance.

From the glacier the river may be seen to have cut its way between the hill and the moraine on the left. No signs of glaciation were noticed on the hill beside the stream, but the rock is weathered and easily split, and striation marks would probably be quickly effaced. Another sign of retreat is the presence of an important moraine ridge, the highest point of which is 50 feet above the glacier. On the free side it rises fully 100 feet. It is passed over in reaching the ice as one ascends from Nangma Tapsa. At the top of the ridge is a huge bowlder, the form and dimensions of which are represented by a cube with a side of 50 feet. The only other branch on the left or east side enters 4 miles from the mouth and is called the Sosbon. On the west side three feeders enter the main stream near the southern end, and 6 miles up another large branch debouches to the west. Altogether there are six tributaries.

June is supposed to be a good month for glacier exploration in the Himalayas, but this season it was not, owing to late, severe, winter storms. Leaving the ridge we were at once on the ice at about 13,500 feet, at which height on other glaciers we have always found either lower mountain spurs or lateral moraines on which to camp, but this season, at the end of June, we found the Hoh Lumba covered completely with a deep mantle of snow, the lower mountain flanks equally so. It was therefore most difficult to judge of the conformation of the glacier or of the moraines.

On the glacier itself lateral moraines were slight or wanting, and medial moraines, if there were any, were so covered with snow that they could not be distinguished. Great snow hillocks extend up and down for long stretches. We were here at about 14,600 feet, a thousand feet above our first glacier camp, the splendid granite peaks in the background appearing foreshortened by this rising terrane.

They represent the general mountain forms seen on the Hoh Lu and are the peaks bordering the west bank leading to the col. T on the east bank are scarcely less serrated and abrupt in characte

To intrude an alpinist's view, I will say that while the scener this glacier is of the utmost beauty, the mountains bordering it mostly quite unclimbable.

The fourth and last branch glacier on the west side is 2⅛ miles l and where it enters the Hoh Lumba not lower than 15,000 feet. face has an unbroken, deep-snow surface, no crevasses even being ible. The peak at its end was triangulated by our topographer, places its height at 22,854 feet. South of this nala, about 5½ mile the glacier, observations were made of the movement of the stream. Observation of the movement at the time we were there very difficult, owing to the masses of surface snow and the cons fall of avalanches from the steep slopes forming the sides of the cier. In fact, only one practicable point for such observation found on the west bank, where the inclination was about 2° 32′ f the horizontal.

At 446 feet from the bank the movement in twenty-four h was 0.16 foot; at a distance of 734 feet it was 0.26 foot. On Chogo Lungma glacier, explored later, the season being more vanced, we found much more satisfactory conditions for this sor work and had better results.

Beyond this branch on the left, as we ascend, the main gla bends more to the north, opening into what has the appearance large, elongated basin, and from this snow-covered rock the g saddle above the source, 3 miles off, is seen.

This depression is the only one in a vast cirque of granite aigu stretching in two long lines from both sides of the ridge. T peaks range from 19,000 to 20,000 feet in height. This ice fall, it is not a pass, is indicated on the Indian survey map as a low s pass leading over to the Hispar glacier. As a matter of fact, ridge over the séracs ends in a huge curling cornice, which overl a glacier, not the Hispar, passing about 7,000 feet sheer below cornice. This saddle, first ascended by us on June 23, is 18,331 high. At the end of the glacier the visible width of the ice fa 624 feet, and the height of the lower sharp fall is 324 feet.

I wish now to draw attention for a moment to the large east bra of the Hoh Lumba, called the Sosbon. On the Indian trigono rical survey map it is drawn as a small branch of the Hoh. It en the main glacier at about 4 miles up and is in reality a glacier ne as long and quite as wide as the Hoh Lumba. It is 5 miles long f its junction with the former to its source at the base of a sa 16,000 feet high, and its course is, approximately, parallel with

Hoh. It is fed by several tributary and hanging glaciers on its east bank. It snowed for two days while we were at Sosbon camp, and all possible knowledge of the glacier's structure had to be gained by plodding about in snow to the knees.

Three well-defined deep ridges follow the sweep of the glacier from the base of the Sosbon peak for 2½ miles down to about the entrance of the first east feeder and we distinguished one strongly marked, short, medial moraine ridge. Below this the glacier is evidently covered with moraine detritus, but it was so covered with deep snow that little detail was observable.

A tall gneissoid rock (Sosbon rock), 22 feet high, stands in the middle of the glacier not far from the camp. The top is divided into five points. Being in the center of the glacier it could not have fallen from the side peaks, but must have descended with the glacier from some peak near its source, 4 miles distant, and it is the more curious that it should have remained standing through an unknown period of time without splitting further. The splendid riven snow-coated rock towers are typical of the border scenery of these two beautiful ice streams.

I will now speak briefly of two high ascents, made from our base camps on the Chogo Lungma the same season. The climbing of a snow peak of over 20,000 feet in the Chogo Lungma region is attended with more difficulties than the ascent of a similar height in Ladakh or the Andes.

First, transport must be taken several marches over a long, complex glacier such as does not exist in South America and can only be compared in size with glaciers of Alaska. Second, the permanent snow line here is much lower. We placed it on the Chogo Lungma at about 16,000 feet. This obviously adds much to the difficulty of making high ascents, as several snow camps must be made and with each successive high camp the courage of your transport coolie diminishes. The uncertain weather conditions, due to the Indian southwest monsoon during the two climbing months of July and August, present another serious obstacle. Some seasons, as in 1902, one does not have more than two clear days consecutively, and then no very high ascents are possible. In 1903, after long periods of storm, five fine days occurred and we seized the opportunity to make an ascent.

The Asiatic Riffelhorn, so named by us because of its resemblance to the Zermatt Peak of that name, is 22 miles up the Chogo Lungma Glacier and is 15,300 feet high. On the summit is a stone cairn built by us, which contains some of the accounts of our different snow trips made from this base. Riffel camp was at 14,000 feet on the flank of the Riffelhorn and was our base for sixty days during two seasons. Its situation in the heart of the arctic Chogo Lungma

tall, silvery peak, still far above, calling loudly to us in the gray-blue dawn.

Coolies are lazy dogs and hate to come out of their tents early, when mountaineers are keen to move upward, and the sun flooded the bivouac before they were again in line. It took several hours to traverse a long ridge, seamed with schrunds and crevasses, for getting the head coolie over a yawning crevasse is onerous work.

Later on Doctor Workman and the second guide remained with the men to coax and help them on, while Petigax, the porter, and I tracked out a way some distance in advance. The head guide was cutting steps up a high wall in zigzag. We much wished to take the coolies up this and over a shoulder running above and then find a flat place for camp. But, alas, a call of warning rang from below, and turning to look down we saw many of the coolies lying on their backs on the snow. The report came that some were mountain-sick and that the others refused to move.

After much conference and various attempts, including offers of money, to make the coolies advance, we returned to the scene of action, or rather inaction. As they remained obdurate, we led them groaning down a few hundred feet and taking a different course steered for a plateau on another side of the main mountain; here we camped at 19,358 feet. It was clear that the coolies could be taken no higher. They even told us they must stay here a few days to recuperate. The peak was still far above, but the only way was to attack it early the next day ourselves and hope for success. The guides went out after it froze and cut steps for a long way to facilitate the coming ascent. The black-bulb thermometer registered 180° F. in the sun and 38° was the shade temperature at 2 p. m.

Having completed hypsometric and other observations, we passed the rest of the day quickly in preparations for the ascent and in cooking dinner over a pioneer's stove. After that we sought sleep in our sleeping bags, but the night was not a restful one at that height, and all suffered from wakefulness and want of oxygen.

At 3 a. m. on the fourth day we left the tent by moonlight, temperature 15° F., and, roped, crossed to the base of the peak, attacking two sharp slants in zigzags. We made much quicker progress than usual at such heights, because of the steps cut the night before; but the gradient was very steep, broken by no mitigating plateau, and rising, as measured by clinometer, at an angle of 60° and over until near the summit. The cold was most severe before sunrise and chiefly affected our feet. As we neared the top they were so delightfully sensationless that we considered taking off our boots and stockings and rubbing them with snow; but vigorous pounding with ice axes at last produced the necessary tingling that meant safety. As we went higher an army of peaks seemed to steal up around us

in the waning moonlight. Shadowy at first, they soon stood clear and ghastly as if marshaled to meet the sun. Then came the glorious after-dawn light of India, a golden red from the horizon creeping upward till the zenith was shot with blood-red fangs.

Next King Sol burst upon the scene, flinging his rays aslant first one summit then another, flooding the whole snowy world with light and color. Feeling the lassitude unavoidable at such a height, we were marching slowly up the last zigzag, and at 7.15 stood on the corniced summit, 21,500 feet above sea level. Through an error in copying the figures the height of this peak was first given out as 21,770 instead of 21,500 feet. The day was cloudless and the view widespread, ranging to the south over Masherbrum, Gosherbrum, the Mustagh Tower, and hundreds of scarcely lesser lights, until the eye was caught by a great dark pyramid hung above a bank of vapor, seemingly in mid-heaven. This was K2, mighty in its rôle of second to Everest and a warning to would-be climbers. Westward came the massif of Nangma Parbat and the snowy form of Itaramosh, 24,270 feet, which looks like the head and spread wings of an eagle. But they were also too far away to be photographed, and we had to content ourselves with recognizing and picking them out. The temperature was 16° F., certainly not cold for the height, and after photographing and taking observations we turned our attention to another peak lying beyond to the north. It rose, apparently about 1,000 feet above, from an elevated plateau, and was separated from our peak by a long ridge.

It was early in the day, and although we gasped a good deal for lack of oxygen on moving, we were fit enough as a whole, and why not have that peak too? Gathering up our ice axes and adjusting the rope, we descended several hundred feet to the ridge. Crossing this, in places heavily crevassed, we reached the plateau, and soon the ascent of the long slopes was in order. The gradient we were now on was much less steep than that of the first peak, a consoling feature at 22,000 feet, and in three hours we stood on the summit of Peak II, a snow slant on the east side and an overhanging cornice on the northwest.

The view was similar to that of the first peak except that the distant mountains appeared higher and we looked down a good deal on the previous summit. Still less oxygen was in the air, and with slower motions we set about taking our observations and readings which, after calculation and comparison with lower station readings, placed the height at 22,567 feet. I had thus broken my old record of 21,000 feet twice on the same day and this time by 1,567 feet.

The southwest upper branch of the Chogo Lungma, which was first ascended by us the second season, is about 6 miles long and ascends throughout its course at a high level, being at its entrance into the Chogo Lungma not less than 17,000 feet. The saddle above

its source is quite 19,000 feet. As we were at a great height here I suppose some mention of our physical condition is in order.

The guides declared that they felt as well as they had felt lower down and they had fairly good appetites. We experienced no nausea, but had severe headaches and were distinctly affected by mountain lassitude. Interest in solid food was also slight. The temperature became really warm toward noon, and we were able to discard all coats, and at 2.30, before we went down, it was 50° in the shade.

The snow conditions in ascending had been good as a whole, but in descending we found that they were much more trying, causing us, after the first hour, to sink into the snow to our knees. We reached camp in fifteen hours from the time we left it, having passed much of that time at an elevation of over 21,000 feet.

We spent another night at the high camp, and on the fifth morning we packed tents and descended to the glacier—none too soon, as it happened, for the weather was becoming bad.

In regard to taking heights, it was our custom at all high camps, and, when anyway possible, also on peaks and passes, to make hypsometric observations, which were compared later with lower-station mercurial barometer readings taken for us by a Government official three times daily at Skardu. Calculations were then made from these observations by three different tables, the average being accepted as the true height. We also carried two Watkins patent aneroids, graduated to 25,000 feet, which were checked daily by the boiling point.

THE MORAINES OF THE CHOGO LUNGMA GLACIER IN BALTISTAN

By W. H. WORKMAN, London, England

The Chogo Lungma, one of the largest of Himalayan glaciers, was ascended and explored for the first time by Mrs. Fanny Bullock Workman and myself during our expedition of 1902. We revisited it again in 1903 to complete our work, and made the record ascents of three peaks at its head, which Mrs. Workman has described.

This glacier lies in the extreme north of Baltistan, between the parallels of 35° 49′ and 36° 5′ north latitude and 74° 55′ and 75° 25′ longitude east of Greenwich. Its lower end, or snout, terminates 1,184 feet above Arandu, the last and highest village in this direction, which is reached in twenty-three marches from Srinagar, the capital of Kashmir, over rough paths, which must be traversed on ponies and on foot.

The region in which the Chogo Lungma lies is covered with immense mountain masses, having bold, precipitous flanks shagged with the acumulated ice of ages, the serrated peaks of which rise from 20,000 to nearly 25,000 feet, separated by deep, comparatively narrow, rapidly descending valleys. The glaciers the latter contain, though not very wide, have great depth of ice, sharp gradients, are seamed by huge, profound crevasses and ice caverns, and their surfaces are split up into tumbling ice falls and séracs of great size. These glaciers embody in themselves potentialities for the exertion of glacial force which are amazing when their surface area only is considered.

The part of this region—and it is a large part—above vegetation consists of an indescribably grand but savage and desolate wilderness of rock, snow, and ice, counting among its features vast slants of driven snow hundreds of feet in depth that supply the source and swell the volume of the glaciers below and rock precipices thousands of feet in height, down which thunder giant avalanches born of the curling snow and ice masses that cornice the brows of the heights above—avalanches such as are probably seen nowhere outside this, the world's greatest mountain chain.

The Chogo Lungma runs in a somewhat curved, general northwesterly course from Arandu for 30 miles, and has its origin in an ice wall the top of which is nearly 20,000 feet above the sea. This ice wall forms a col or saddle between two snow summits of about 24,500 feet altitude, the higher of which dominates the whole region. This col we named the Pratap Singh La in honor of His Highness the Maharaja of Kashmir.

The width of the glacier varies from about a mile near its lower end to 2 miles in its upper middle part. It ascends from 9,500 feet at Arandu to 19,000 at the base of its wall of origin. It has nine large glacial tributaries, five of which we explored to their origin, and as many smaller ones.

The mountains walling in the Chogo Lungma and its tributaries are composed of shales and granitic rocks. Many of these are brittle, soft, and crumbling, offering comparatively little resistance to the action of sun, frost, and weather, which cause the exposed rocks to disintegrate at a rapid rate. Many of the surface quartzites and sandstones are so decomposed that they can be rubbed into sand between the fingers.

An immense amount of débris is discharged upon the glaciers, which accumulates along their sides, the larger fragments reaching even to their central portions.

As is well known, when two glaciers unite to form a larger one, or when a tributary enters the main stream, the débris on the side of one, mingling with that of the corresponding side of the other, is carried down in the line of union more or less toward the center of the resultant glacier and being upraised by the lateral pressure forms a medial moraine. The débris on the outer edges of the glaciers is borne along as before and later is extruded on the glacial banks to form lateral moraines. With the junction of every branch a new medial moraine may be formed, till a glacier may bear on its surface several well-marked medial moraines.

For the first 8 miles after its origin the Chogo Lungma, owing to the ice-bound condition of the mountains and also to the fact that it receives but one important branch formed under the same conditions, shows but little débris and no moraines. In this 8 miles it falls 5,000 feet, and in consequence of the sharp gradient its surface is much broken, presenting three series of ice falls, and many crevasses and séracs.

During the next 10 miles the glacier receives several large tributaries on both sides, some of them heavily laden with rock débris. The appearance of the glacial surface now changes. It becomes banded with a series of remarkable medial moraines, of which I counted from a height 6 well-marked ones. Some of these consist

of several ridges, which are in reality separate moraines, so that in places the number may be estimated at between 12 and 20.

The largest branch, the Haramosh Glacier, originating under the flanks of Mount Haramosh (24,285 feet), 10 miles to the southwest, with a width of more than three-fourths of a mile, impinges on the Chogo Lungma at a right angle, with a force so great that the latter is crowded bodily over toward its left bank, and the Haramosh, turning with a great sweep to the right, wedges itself into the glacier bed, forming thenceforth nearly half of the Chogo Lungma for a distance of several miles before losing its identity.

The débris brought down on the left side of the Haramosh Glacier forms at the line of junction with the Chogo Lungma along the middle of the glacier a medial moraine, which is pushed up high above the surrounding level by the lateral pressure of the two streams. This moraine, at first small, increases rapidly in width and height, until it becomes the largest moraine on the glacier. It is composed almost entirely of granite stained red with iron. About a mile below the junction of the two glaciers another moraine of black granite and shale, the source of which is not apparent, suddenly springs up by the side of the former one, and increases in size till it reaches a height of more than 150 feet, quite overtopping its neighbor. It is cleft by large transverse crevasses of unknown depth. After 4 miles these two moraines, sinking nearly to the level of the white ice, coalesce into one, which assumes a dark color.

The débris on the right edge of the Haramosh Glacier, together with that of large branches on the right side below, forms a series of medial moraines which cover and blacken a wide belt on the right side of the Chogo Lungma. The same is the case to a less degree on the left side of the Chogo Lungma, where the moraines do not encroach nearly so far on the white ice. The branches on this side are smaller than those on the south side.

The medial moraines mark the courses of different ice currents, of which there are many. The direction of these currents varies considerably, depending on the pressure exercised at different points, so that the moraines are seen from above to run a serpentine course. Their rates of movement also vary among themselves, ranging according to measurements made from two stations, from 580 to 1,200 feet per annum, which shows that the glacier advances not in a solid column, but by sections.

Nine miles from the end of the glacier white ice disappears from view, and the medial moraines lose their individual ridges, sink to the general level, and mingle together in a common mass. The surface of the ice loses all regularity of arrangement and becomes broken up into a confused labyrinth of pointed and rounded hillocks, sharp

AMONG THE SÉRACS OF THE CHOGO LUNGMA GLACIER.

LOOKING DOWN THE CHOGO LUNGMA, SHOWING THE MEDIAL MORAINES.
Taken from an altitude of 16,000 feet.

ridges, and deep ravines, so thickly covered with detritus, consisting of mud, sand, shale, fragments of granite and quartzite, and bowlders of the same, some of them being of immense size, that the ice itself can only here and there be seen. This formation continues quite to the end of the glacier.

What becomes of the vast quantity of detritus here accumulated is a mystery. There are no lateral moraines near the end of the glacier of sufficient size to account for its disappearance, and the glacier ends in a rather small snout that shelves down to a thin edge and dies out on the river bed without forming any terminal moraine whatever.

Owing to the broken condition of the surface and the steepness of the mountains on its south side the glacier has to be ascended for the first 14 miles in a space on the north side between it and the mountain wall left by its recession. This space varies from 50 to 600 feet in width and contains a large number of lateral moraines that tell an interesting story. It is here that the lateral moraines are best seen. The largest and oldest of these are those that border the mountain slopes, some of which, formed long ago, are covered with vegetation and trees. Then come others, parallel to them, of various sizes and lengths, and, lastly, the moraines now adjacent to the ice, some of which are large and high and others just beginning to be formed.

At one point I counted five parallel moraines between the oldest one and the ice wall of the glacier. From these we learn that the glacier has diminished greatly in width on this side, and that the recession has been going on for a long time, with intervals when the ice was stationary or slightly advancing, when the intermediate moraines were built, and that this process is still progressing, as shown by the fact that the ice has shrunk away from the line of moraine last formed.

At one place a large primary moraine stands at least 100 feet above the present level of the ice opposite it. To build this moraine the ice must have been 150 to 200 feet higher than it now is, which represents an important shrinkage in thickness as well as in width.

In this connection it is interesting to note that several of the tributary glaciers on this north side of the Chogo Lungma have receded greatly, two large ones having retreated up their valleys, so that they no longer feed the main stream. Their beds just above their former junction with it are covered with a chaos of débris left by the melting ice, and the mountain walls on each side are banded by giant moraines, which, with the void between them, bear witness to the large volume of ice that has now vanished. The glacier in the lower part of the Balucho Valley, here shown, must have been at least 250 feet thick where now little or no ice is seen.

In some of the smaller valleys the tributary glaciers have entirely

disappeared. The southern tributaries, which originate in the higher and more snowy mountains of the Haramosh Range and have a northern exposure, do not appear to have receded to any extent during recent years.

At some points on this range side moraines are in process of formation, the melting of the ice setting free its burden of fragments, which slide down the sloping flank and accumulate at its base. In all parts of the glacier, examples of nature's law of destruction of her previous work and upbuilding of new structures out of the resulting débris may be seen.

The Chogo Lungma, with its branches, offers a more complete study of moraine formation, both medial and lateral, than any other glacier I have seen. Its failure to build any terminal moraine whatever, where one or more large ones might be expected, makes it still more remarkable.

	Number of species.	
	English.	Our expedition.
Astragalus	8	30
Compositæ	54	180
Gramineæ	32	80
Oxytropis	6	25
Gentiana	9	30

(7) Three hundred skins and 10 complete skeletons of mammals. Among the rodents already worked out (the study of other mammalia is not yet finished), there are the following six new species:

Sciuropterus buechneri Satunin.
Spermophilus pallidicauda Satunin.
Gerbillus kozlowi Satunin.
Nus (Leggada) gansuentid Satunin.
Urocricetus kamensis Satunin.
Microtus kaznakowi Satunin.

(8) About 1,400 skins, several skeletons, nests, and eggs of birds form the ornithological collection. The study of this collection is far from being finished, but among the birds there are embraced the following novelties:

A new subspecies of jackdaw, *Coloeus dauricus major*.
A very original species of bunting, *Emberiza koslowi*, without near affinities.
A new subspecies of shore lark, *Otocorys elwesi khamensis*.
A new species of creeper, *Certhia khamensis*.
A new subspecies of alpine accentor, *Accentor collaris tibetanus*.
A new genus and new species, *Kaznakowia koslowi*, of the family of Timeliidæ.
A new species of sparrow-hawk, *Accipiter ladygini*.

Moreover, the large collection of the expedition has permitted us to establish a new genus, Koslowia, the type of which is *Leucosticte roborowskii* Przew., brought by Przewalski in one single specimen.

All these new species of birds have been established by Mr. W. Bianchi, the learned keeper of the ornithological section of the zoological museum at the Academy of Sciences, St. Petersburg.

(9) Among fishes caught by the expedition are four new species:

Schizothorax kozlovi Nicolski.
Ptychobarbus kaznakovi Nicolski.
Nemachilus altipinnis Nicolski.
Nemachilus crassus Nicolski.

The other vertebrates (snakes, lizards, amphibians) are still under examination.

(10) The collection of insects comprises about 30,000 beetles, from which already several new genera and new species are described. Further, there are thousands of other insects, some of them either new or very rare.

observations were made, 70 for latitude (⊙, Polaris, etc.) and 65 for longitude. The survey was made on a scale of 1 : 420,000, or about 6.6 miles to an inch.

(2) Thirty-seven points have been fixed astronomically. Out of these 37 points I give but 20 whose longitude was determined.

Name of the place.	Latitude.	Longitude east of Greenwich.		Altitude.
	° ′ ″	h. m. s.	° ′ ″	Meters.
The town of Kobdo	48 1 8.9	6 6 24.4	91 36 6	1,370
Khulmu-noz (lake)	46 12 57.7	6 14 16.2	93 34 0	2,200
Dzak-obo (site)	46 12 35.9	6 21 44.3	95 26 0	970
Dzughin-budl (site)	45 48 48.3	6 28 48.2	97 12 0	1,865
Dalynturn (source)	45 7 18.5	6 35 55.1	98 59 0	2,280
Orok-nor (lake)	45 3 40.7	6 43 17.5	100 49 0	1,130
Seiren khaia-khuduk (well)	45 5 19.1	6 45 11.2	101 17 48	1,160
Khungureghin-aro-gol (source)	44 59 11.0	6 47 51.3	101 58 0	1,370
Ch'ats'eringhi-khuduk (well)	44 28 27.0	6 52 35.5	103 8 53	1,130
Ch'ortentan (monastery)	36 56 24.6	6 48 52.4	102 43 6	2,265
Baron ozassak fredi (source)	36 10 55.1	6 29 27.0	97 21 47	2,860
Lung-tok-ndo (the winter quarters of the expedition)	31 30 55.1	6 29 15.9	97 18 59	3,645
Bana-jun (village)	31 59 55.1	6 37 28.1	99 22 2	3,665
Grdeni-bulyk (source)	36 55 31.3	6 33 37.1	98 24 17	2,960
K'uan-kou-ch'êng (town)	37 9 45.3	6 53 22.1	103 21 0	2,490
Ting-yüan-ying (town)	38 49 59.9	7 1 7.1	105 17 0	1,515
Ulan tatal (well)	39 13 10.6	7 0 24.4	105 6 0	1,225
Khara-sukhai (well)	40 46 56.9	6 57 17.9	104 19 0	1,315
Shing-kober (well)	43 17 22.5	6 54 32.2	103 38 0	1,595
Urga (Russian consulate)	47 54 57.5	7 7 50.0	106 57 30	1,325

(3) The altitudes of about 1,000 points have been determined by means of a mercurial barometer.

(4) The meteorological instruments were read during this whole voyage (September, 1899–January, 1902), thrice a day (7 a. m., 1 p. m., 9 p. m.), and at the meteorological station in Ts'aidam. The instruments at the station were read at same hours during the fifteen months (May, 1900–July, 1901) the station was in working state and in addition all the instruments have been read every hour from 7 a. m. till 9 p. m. during a full month in the midst of the summer, of the autumn, of the winter, and of the spring.

(5) Limnological observations and collections have been taken, for the first time in inner Asia, by means of a small collapsing boat brought from St. Petersburg, as well as soundings of several lakes, small and large, on the route of the expedition, e. g., on the Orin nor (upper Hoang ho).

(6) Six hundred species of plants, in 25,000 samples, from Kham, were the botanical booty of the expedition. I may state, on the authority of Hemsley ("The Flora of Tibet," Journal of Linnean Society (London), Vol. XXXV), that the English travelers to Tibet brought back from that country but 295 species of plants.

The following comparative list of the number of species of some of the genera and families, brought back by the English and by us, may prove of interest:

	Number of species.	
	English.	Our expedition.
Astragalus	8	30
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(10) The collection of insects comprises about 30,000 beetles, from which already several new genera and new species are described. Further, there are thousands of other insects, some of them either new or very rare.

(11) The plankton from inland lakes of innermost Asia have come under examination for the first time.

(12) Large petrographical and paleontological collections, numbering over 1,200 specimens, have been made.

The publication of the reports, as well as of the scientific results of the expedition, has been undertaken by the Imperial Russian Geographical Society.

There will be two volumes of general reports—Volume I (in press), my personal report, with 4 large maps at 1:840,000, one at 1:4,200,000, and 55 full-page illustrations in collotype; Volume II, the reports of my two companions, with 4 maps at 1:840,000 and 5 full-page illustrations in collotype, to be published next year.

The scientific results will be published in five volumes, with plans, diagrams, and about 40 tables of illustrations (22 in color and 18 in black and white).

It is expected that the whole work will be published in four or five years. The council of the Imperial Russian Geographical Society has appointed an editor, Mr. A. Grigoriev, now honorary member, and for twenty years past the secretary of the society.

WHERE ARE THE KUEN-LUN MOUNTAINS?

By KOZUI OTANI NISHI HONGWANJI, Kyoto, Japan

Historically speaking, none of the nations except the Chinese has ever given any attention to the Kuen-lun Mountains, and therefore it will not be considered unreasonable to say that the ancient and modern Chinese records, from which we shall hereafter quote, have the sole claim to determine the position of the real historical Kuen-lun Mountains.

On investigating the most authentic records of China, we find that about forty-one hundred years ago the term " Kuen-lun " as the name of a tribe was already mentioned in " Yu-kung," but it appears for the first time as the name of a mountain range which stands at the waters of the Hwang-ho (the Yellow River), in a book compiled in the twelfth century B. C., thus:

Urh-ya says:

The Hwang-ho rises in the wild land or high plateau of the Kuen-lun Range, and its water is of a white color.

The record is very simple, but it is the oldest which indicates the Kuen-lun Range as the mountains where the source of the Hwang-ho lies.

The next record is found in Shan-hai-ching, an old Chinese geographical book compiled before the second century B. C. It says:

The Hwang-ho flows from the northeastern corner of the Kuen-lun Range, turning and flowing along its southeastern side, and at last empties its contents into Po-hai.[a]

This is also very simple, but it shows that the ancient Chinese people knew the location of the mountain range, though their knowledge of it was very dim.

And this is the real position of the mountains in question, and none of the Chinese geographers, ancient or modern, can deny that the Kuen-lun Range stands at the headwaters of the Hwang-ho River.

But two historical errors have led to the present misunderstanding of the position of the Kuen-lun Mountains; the one made the moun-

[a] Po-hai is the Gulf of Chi-li.

tains a subject of mysteries and superstitions, while the other snatched away the name "Kuen-lun" and transferred it to another mountain range far beyond the real Kuen-lun Mountains.

(I) "Han-shu" (the history of the Han dynasty) quotes the following passage from a very ancient record, Yu-pen-chi (a life of King Yu):

The Kuen-lun Mountains being 25,000 li[a] high, the sun and moon produce light [day time] and darkness [night], respectively, as they revolve around it.

The mystery about the Kuen-lun Range became greatly increased by the priests of Taoism, which is even now the most powerful religion among the Chinese people. Taoism, though already in existence in the third century B. C., began to flourish among the people in the third century A. D., and in contradistinction to Buddhism, the Taoists had produced many sacred books about their religion. In their books we find a statement that the residence or paradise of their forefather, Lao-tse, is on the summit of the Kuen-lun Range, with very fantastic, mysterious descriptions of those mountains. The following cosmographical passages of the Taoist sacred books are quoted in Hsiaw-Tao-lon, which exposed the fact that the Taoists compiled their sacred books mostly from materials stolen out of the Buddhist Tripitaka, with many absurd additions.

(*a*) Lao-tse at last transfigured his form, his eye becoming the sun, his right eye the moon, and his head the Kuen-lun Mountains.

(*b*) Lao-chun [viz, Lao-tse] transfigured his head and it became the Kuen-lun Mountains.

(*c*) While the universe was in a chaotic state, Lao-chun commanded his subject Lin-hu-hai to create the sun and moon within the darkness. South of the Kuen-lun Mountains, 30,000,000,000,000 li distant from them, there is another Kuen-lun Range, and arranged in such a way 1,000 Kuen-lun Mountains taken together form so-called one lesser thousand cosmos.

Thus the Kuen-lun Range became entirely legendary, till at last it became confounded with Mount Sumeru, which is believed to be the central mountain of each universe, as related in the ancient sacred books of India.

(II) Chan-chien was the first Chinese who opened communication between China and Si-yu (the modern Chinese Turkestan) and explored the countries Si-yu, Persia, etc. He was dispatched to Tai-hsia, viz, Bactriana, by Wu-ti, the Emperor of the Han dynasty who had a great ambition to conquer the neighboring states, and was inclined to do anything to glorify his empire, aggregate his dominions in every direction, and to do anything novel to increase his fame in history.

Chan-chien came to Si-yu (the modern Chinese Turkestan) en route to Tai-hsia, viz, Bactriana, and saw a river flowing eastward—

[a] One li is equal to 0.30 geographical mile.

probably the Tarim River or Yarkand Daria. He took it to be the upper stream of the Hwang-ho (the Yellow River). The Life of Chan-chien in Han-shu (the history of the Han dynasty) says:

> The envoy [Chan-chien] explored the source of the river [the Yellow River]. The mountain [the fountain head of that river] is rich in jade, and he brought some home. The Emperor [Wu-ti] was greatly pleased, and, consulting some old book, he named the mountain "Kuen-lun."

What books the Emperor consulted is not mentioned, but they perhaps were those of Urh-ya or Shan-hai-ching, which we have mentioned before. Anyhow he firmly clung to the idea that the fountain head of the Yellow River is in the Kuen-lun Range.

Chan-chien and Wu-ti made a gross mistake. Primarily, the former took a quite different river as the upper course of the Yellow River, and accordingly the latter, who obtained his information from Chan-chien, located, with the Emperor's edict, the Kuen-lun Range (that is, the fountain head of the Hwang-ho) among the mountains on the south of the town Yu-tien (Khotan). Thus the mountains on the south of Khotan in Chinese Turkestan became known as the "Kuen-lun Mountains" among the Chinese, and as the Europeans have simply followed the Chinese, the real Kuen-lun Range has been thrown into obscurity.

It is not strange that the name "Kuen-lun" was thus transferred to the mountain range on the south of Khotan as the geographical knowledge of the ancient Chinese extended its domain westward since the time of Chan-chien, for such transfers have not been infrequent. In the same way the name Tien-shan extended itself westward to one mountain after another as the Chinese authority claimed its suzerainity over one country after another toward the west in the "western region" (Chinese Turkestan). But in the history of China we find record here and there of many undaunted explorers who attempted to search out the source of the Hwang-ho in the Kuen-lun Range through those least known mountainous regions. Whatever their exertions were, they could not free themselves from the authority of the Emperor Wu-ti: nay, they strove their utmost to verify the mistaken edict of the pedantic Emperor.

Now, let us examine how desperately the Chinese geographers of several dynasties tried to reconcile the results of explorations and the mistake of Wu-ti, the emperor of the Han dynasty.

(1) Thiu-Ching-Chu (a work of 500 or 600 A. D.) says:

> The plateau of the Kuen-lun Range lies in the northwest of China proper, it being 50,000 li distant from Lung-shan, a mountain in Honan Province, standing in the center of the earth. It is also called Anavadata Mountain.

In the Buddlist sacred books of India, Anavadata Mountain, which is said to stand north of the Himalaya Range, beside a lake of the same name, is very often alluded to in connection with the Naga

tribes, and also as the location of the fountain heads of the four great rivers. For the identification of the Kuen-lun Range with Anavadata Mountain, the author has taken great pains to reconcile those passages which he has quoted from various Chinese and Indian works, but the result of his labor seems not to be successful. The descriptions of Anavadata Mountain and Lake given by the different authors do not agree with each other; while in the modern maps and records of central Asia we can not yet find such a lake as corresponds to either of them.

(2) Kwo-ti-chi (a work of 700 A. D) says:

Mount Anavadata is called "Chien-mo-ta shan" or Mount Kuen-lun. * * * The Hwang-ho starts from the mouth of the Ox-head Rock in the northeast and flowing eastward empties its contents into the Ten-tsaio [Lake Lop-nor], and from hence taking a subterranean course to the great Chi-shi-shan [a mountain] it again bubbles up; and then, at the foot of the Hwa-shan [a mountain rising 10 li south of the Hwa-yin district in Honan Province], bending its course to the northeast till at last it empties itself into the sea. * * * The Mount Anavadata, or the great Kuen-lun Mountain, is situated 15,370 li southwest of Yung-cho [the present Si-an-fu in the province Shen-si.]

We have one mountain also called "Kuen-lun," in Su-chou [a district in Kan-suh]; but it is the lesser Kuen-lun.

This description is evidently a repetition of that given in Shui-ching-chu, with some modification.

(3) Tai-ping-hwan-yu-chi (a work of 1000 A. D.) gives an account of Kuen-lun which is almost identical with that in the foregoing book, but with the following passage added to it:

The Sho-pa River [the Khotan River] and the South River of the Tsung-ling [the Yarkand River] uniting together run into the Yen-tse [Lake Lop-nor], taking the name Chi-sho-shui [the Tarim River.]

Coming down to the middle of the eighteenth century, we have many great geographical works which enter minutely into the present subject, but we shall here give short summaries of only three of them as examples, because their arguments do not differ greatly from one another, all adhering to the above romantic tradition; thus

(4) Hwang-chau-tung-chi (a work of 1800 A. D.) traces the head-waters of the Hwang-ho (the Yellow River) to the Gadasuchilau peak of the Baian-kara-ula Range; but clinging firmly to that mysterious record contained in Han-shu, says that the river which comes from the peak mentioned is the second source of the Hwang-ho, which there bubbles up from its subterranean course, and that the Kashgar River, Yarkand River, and Khotan River, forming the first sources of the Hwang-ho, all come from the Kuen-lun Range, which stands on the western boundary of Hwei-pu (Sin-Ching Province—that is, Chinese Turkestan), and after emptying their contents into the Pu-Chang-hai (Lake Lop-nor), arrive at the second source of the Hwang-ho.

(5) Ta-ching-yi-tung-chi (a work of 1800 A. D.) states that the water which comes from Lake Lop-nor through the subterranean drain bubbles up again, not in the Tsi-shi-shan (a mountain), but at the very source of the Althan River. As to the location of the Kuen-lun Range it denies the record of Yuang-Shih, which puts it in the present Amneh-machin-mus Range (amneh means farther, machin precipitous, and mus ice, therefore amneh-machin-mus is the farther of the lofty snowy mountains) east of the Starry Lake; nor does it accept the Baian-kara-ula Range (baian means rick, kara black, and ula mountain, therefore Baian-kara-ula[a] is the very bright black mountain), which is identified with the Kurkum Mountains of the Mongols, as well as with the Great Tsi-shi-shan of Kwo-ti-chi, and even with Mount Tsi-shi in Yu-kung, while the position of the mountain range is not directly indicated.

We can easily perceive by reading through the long argument that the authors' aim has been to bring all the reports of the explorations into consistency with the tradition given in Han-shu, and thus to escape any objections which would be brought to bear upon their investigations by their opponents. This caution, though strange enough to our readers, is made more conspicuous in the following work.

(6) Si-yu-tu-chi (a work of 1800 A. D.) identifies the Kuen-lun Range with Mount Anavadata, and says that Mount Anavadata, now generally called Mount Kangtis (which is in the southern part of the Bong-thol region, according to the Tibetan map of the Royal Geographical Society), is situated southeast of the Tsung-ling Mountains and the western part of Tibet. The Kuen-lun Mountains there form a complicated range, whose branches on one hand join the Tsung-ling Range on the northwest, and Mount Kurkun on the northeast, at the fountain head of the Hwang-ho, where its source is composed of many small streams. Those which come from the southeastern valleys of the Kangtis Mountains, after leaving the foot of Mount Kurkun, empty their contents into the Starry Lake, and thence flow to the foot of the Tsi-shi-shan Range; while those which flow from the northeastern valleys, after leaving the Tsung-ling Range and the mountains south of the town of Khotan, arrive at Lake Lop-nor, and thence, taking a subterranean course to the Tsi-shi-shan Range, at last meet with the river which comes from the Starry Lake.

From the above summary it will be seen how the authors are compelled to maintain the ancient traditions, while they themselves are inclined rather to accept the results of the explorations as to the real

[a] "Kuen-lun" is not the Chinese word, but the transliteration of some foreign word. Some Chinese scholars think it is derived from the word "kara" (black). In the ancient time the Chinese called the black people inhabiting some southern tropical region (probably Indo-China) by the name "Kuen-lun." So "Baian-kara-ula" has a close relation to "Kuen-lun," even by this way.

situation of the Kuen-lun Mountains. In fact, under such a despotic government as the Chinese no one is exempt from punishment who opposes that which, whatever it may be, is contained in the ancient records and adopted by the sovereign, who is the sole authority for all things. Now, the view which maintains the double source of the Hwang-ho was that which was authorized by the Emperor Wu-ti, of the Han dynasty, and was in the time of the authors adopted by the court, not from geographical points of view, but in order to deify the river as well as its fountain head. Hence, those who were authorized to compile these works must have been obliged to submit their own conclusions to the imperial authority, even the investigation of the present subject. Therefore, we must be far more inclined to sympathize with the condition under which they worked than to blame their imperfect arguments, based, as they are, on the most feeble grounds.

But, fortunately, we are not without the testimony of a few Chinese geographers who devoted themselves to study for study's sake—that is, not bewildered by the authority of the august Emperor, they tried to bring the real Kuen-lun Range into the light, and we are greatly indebted to them for their indefatigable researches to solve this aged problem. The records hereafter quoted are taken from the reports of these explorations from which most of the ancient traditions were expelled as fantastical.

(1) Tung-tien (800 A. D.):

The report that Chan-Chien passed over the upper course of the Hwang-ho, that is, the Khotan and Yarkand rivers in the southern and western parts of the Takla-makhan desert (1), the record that some beautiful gems found in the upper course of the Khotan River were presented to the Emperor Wu-ti (2), and the documents (among which Yu-pen-chi seems to be included) which describe the relation of the mountain and the river, preserved in the imperial library (3): those three factors seem to have induced Wu-ti to name the mountains which contain the headwaters of the Khotan River Kuen-lun.

Out of this interpretation, which was some time after blended with the passage in "Yu-kung," which states that Great Yu traced and dredged the Hwang-ho from the Tsi-shi-shan Range, there was formed the tradition that the Hwang-ho, which starts from the mountain south of the town of Khotan (the first source), after flowing into Lake Lop-nor and taking a subterranean way to the Tsi-shi-shan Range, again bubbles up from the earth (the second source) and thence empties its contents into the Po-hai [sea]. This tradition must have existed many years before the period of Pan-ku, viz. before the second half of the first century A. D., because he quotes as a tradition in Si-yu-chwan in his "Han-shu" [a history of the Han dynasty]. But Pan-ku himself never assigned any importance to it, and he says in another place that Chan-chien might have seen the headwaters of the Hwang-ho, but he had never seen the Kuen-lun Range, and that those traditions relating to the place which lies outside of the nine province, given in Yu-kung, can not easily be believed. In fact, during the period of the former Han dynasty [202 B. C.–9 A. D.] various tribes of the Chiang occupied the region where the fountain head of the Hwang-ho is found; and as these wild tribes, being in a scattered state (such

as it was), were of too little importance to attract the attention of others, the Chinese people were rather ignorant of this southwestern region. Now, according to our investigation, the Hwang-ho, running down many thousand li in the northeastern direction from the Tu-fan domains, must arrive at the foot of the Chi-shi-shan Range, because, firstly, all the envoys sent to Tu-fan [Tibet] state the same; secondly, the natives of Tu-fan report that the Kuen-lun Range which contains the headwaters of the Hwang-ho, is situated in a southwestern direction from the boundary of that country, viz, from the boundary of China and Tibet; and, thirdly, investigating the location of the region occupied by the Chaw-Chi tribe, the neighborhood of the Kuen-lun tribe, mentioned in Yu-kung, must have been in the west of the Chi-shi-shan Range—that is, the former tribe must have occupied a tract lying along the upper course of the Hwang-ho. But among our geographers we meet with some who, adhering firmly to the ancient documents, strive to maintain such an unreasonable and fantastic tradition as mentioned in Si-yu-chwan in Han-shu. In fact, there can not be any more erroneous notion than that the Hwang-ho has a double source.

From this passage we see that some years before the middle of the eighth century A. D. some Chinese writers were already locating the Kuen-lun Range neither in the western part of the Nan-shan Range nor in the Chi-shi-shan Range (the Amneh-machin-mus Range), but in the northeastern part of Tibet.

(2) We have, in the two annals of the Tang dynasty, a narrative, Chin-tang-shu (1000 A. D.), which states that the exploration carried on by Liu-yuang-ting (an ambassador sent from China to Tibet in order to negotiate a peace with it) in the beginning of the ninth century A. D. verified the above report of the Tufans (Tibetans) thus:

According to the report made by Liu-yuang-ting, in the year 822 A. D., after crossing over the Hwang-shwei [a river], he, with other officers, saw the Sha-hu-chuan [a river] in a northwestern direction from the Lung-chuan-ku [a valley].

The Lung-chuan-ku contains the confluence of the Hwang-ho and Hwang-shwei. In the upper course of the former more than 2,000 li [a li being equal to 0.30 mile] southwest of Hung-chi-chian, the river carries down a comparatively small quantity of water. When his party had marched upward more than 300 li southward along the course of the river they arrived at its headwaters, which lie among three precipitous peaks, the middle of them being highest. These three peaks taken together are called by the natives the Tzu-shan [the purple-colored mountain] or the Mu-mu-ri-shan, but to ancient people known as the Kuen-lun Mountains. Near these mountains the waters of the Hwang-ho are very clear and are carried down very gently, but after collecting many tributaries the color of the water changes at first into red and then into darkish yellow. The position of the three peaks—that is, the Kuen-lun Mountains lies within a distance of about four military posts [the distance between the posts is said to be about 200 li—60 miles—therefore that of four posts must be some 800 li] westward from the military post of Tufan,[a] 500 li distant southwestward from the end of the Mo-ho-yen-chei [a desert]; and its bearing from China proper is west of Chien-nan [that is, present Cheng-tu-fu,

[a] Tu-fan (Tibet) was so powerful a country in the ninth century A. D. that when it was threatening to overwhelm the Chinese ascendency the Emperor of the Tang dynasty rather humbly concluded a peace with it by giving the princess Wen-cheng as wife to its king.

in Se-chuan Province]. The Mo-ho-yen desert is gradually narrowed from the west of Sha-chou [a] toward Tu-yu-hun [b] on southeast, and its narrowed part is called the end of the desert.

Now let us examine the position of the mountains above given. According to Ta-ching-yi-tung-chi the Hwang-Shwei or Si-ning River flows northwest of Si-ning-fu and east of Ching-hai (Koko-nor), its upper course being known as the Kun-tu-lun River. The Lun-chuan-ku is a valley in the southwest of Lan-chou. Hung-chi-chian is in the region of Ho-chu (the west tract which has its center in north latitude 36° 39′, east longitude 101°, and therefore it differs from Ho-chu mentioned by Playfair in The Cities and Towns of China, p. 111, which has no connection with the region under consideration). Of the distances given it in the above passage, we have the following reference, viz: In the age of the Tang dynasty the road from China proper to Tibet did not wind upward from the region of Ho-chu along the course of the Hwang-Ho, but took a straight course in a southwesterly direction. Therefore, the Kuen-lun Mountains, which were explored by Lin-yuan-ting, must in all probability be located in the present Baian-kara-ula Range. The end of the Mo-ho-yen-chi, according to the parenthetical note given by the author, must be the present T'saidam region, because the T'saidam region was, in the age of the Tang dnyasty, called the tail or end of the Ta-liu-sha (viz, the Great Moving Sand, or the present Takla-makhan Desert).

The position of the Kuen-lun Mountains, pointed out by Lui-yuan-ting, was again taken up and more minutely examined by Ou-yang-ming (an eminent geographer of the Tsung dynasty), in the beginning of the eleventh century, A. D., and the Yu-ti-kwang-chi contains very interesting criticisms passed by him on the investigations of the present subject as carried on by the earlier geographers.

3. Coming down to the period of the Yuan dynasty (the Mongolian dynasty), we have another discourse on the subject, Wen-hsien-tung-kan (1400, A. D.), given by the well-known Chinese investigator, Ma-twan-lin. His view on the location of the Kuen-lun Mountains in short is this:

That Great Yu surveyed and dredged the Hwang-ho River, from the foot of the Chi-shi-shan range, and that the fountain head of the river lies in the Kuen-lun Mountains. These two are unquestionable historical facts, but the descrip-

[a] Sha-chou is a post town near An-si, which is in north latitude 40° 15′, east longitude 94° 39′, according to Playfair.

[b] Tu-yu-hun was a tribe which was so powerful in the Sui dynasty (581–618 A. D.) that it sometimes seemed likely to overthrow the Chinese Empire. In the beginning of the Tang dynasty (viz, in the middle of the seventh centruy) this tribe, having its headquarters near Ching-hai (Koko-nor Lake), was plundering the northwestern part of China Proper. The boundary of the region occupied by it is indeterminate, but it seems to have extended in the north as far as Kan-chow and Liang-chou, in Kan-suh Province, in the west to the Lake Lop-nor, and in the south to the headwaters of the Hwang-ho—that is, the present Baian-kara-ula Range.

tion and interpretations conferred upon them by ancient as well as modern scholars are all false, except those of Tun-tien and Yu-ti-kwang-chi, both of which give us very clear and exhaustive investigations; therefore, we especially quote them here uder the record of the Chi-shi expedition.

4. Some years ago before Ma-twan-ling had finished his great work, General Tu-shi, as the explorer of the headwaters of the Hwang-ho, was sent to the Tibetan region by the Emperor Shih-tsu (Kublai) of the Yuan dynasty; and his report is preserved in "Ho-yuan-kan" (an investigation of the source of the Yellow River, 1400 A. D.), annexed to the book of geography in Yuan-shi, as follows:

The great Mongolian conqueror Shih-tsu, as his conquests extended, ordered military posts to be established throughout his dominions to facilitate the work of mounted couriers traveling in all directions, so that at that period the greatest Empire which the world had ever seen seemed as if it were contracted within narrow limits, and all such things as the subjugation of rebellions, exploration of unknown regions, and the like, came to be performed without any difficulty.

Thus, in the year 1280 A. D., by imperial order the surveyor-general, Tu-shi, started for the exploration of the headwaters of the Hwang-ho. Marching eastward from Ho-chou [a town belonging to Kan-suh Province] via the military post of Ning-ho, he crossed over the Sha-ma-kwan pass, and then taking his course to the west arrived at the fountain head of the Hwang-ho after spending full four months on the journey. Many years after his exploration the imperial academician, Pan-ang-hsian [a younger brother of Tu-shi], published it as "Ho-yuan-chi" [a record of the source of the Yellow River]. Chu-se-pen (a native of Lin-chwan) also finding a Sanscrit geographical maunscript describing that region, a work which was originally the property of the imperial teacher of Buddhism and preserved in the library of Tari-chi-se (a Mongolian gentleman), published a translation of it.

Comparing Ho-yuan-chi with the translation, we find that they differ in some points from each other, but the information common to them is this:

In a valley far distant to the west of Dokansy of Tufan some hundreds of small fountains are seen bubbling up here and there on a ground extending over 70 square li or more, and when they are looked down upon from a height their glittering surfaces seem to be like a cluster of sparkling stars. Therefore the natives call this part of the valley Odon-nor [signifying the starry lake, from Odon, meaning star, and nor, lake]. In the northeast of Dokansy there is a great snow mountain, which is called "Yirmapumola" by the Mongols (the latter name being only a translation of the former), and this mountain is, in fact, the real Kuen-lun Range. The waters which overflow from the Odon-nor and pass through two lakes named Charing and Oring, after descending the eastern slope for a distance of six or seven days' journey, are called for the first time the Hwang-ho, but at that part the contents of the river are very clear. After the river has continued its eastward course for a distance of six more days' journey it at last assumes a darkish yellow color. The river flows in a semicircular form along the southern side of the Kuen-lung Range.

Now, as General Tu-shi and the Tibetan geographers identify the Kuen-lun Range with the Tengri-tagh Mountains, that is, the mountain range known to us as the Amnch-machin-mus (signifying the father of the lofty, snowy mountains), running from west to east in

north latitude 34° and east longitude 99°–101° 20′, their Kuen-lun Range is seen to be located, not at the fountain head of the Hwang-ho, but far down the course of the river; and therefore the result of the work carried on by them failed to point out the correct position of the Kuen-lun Mountains. But we ought not for this reason to overlook the relation between the Starry Lake and the lakes of Charing and Oring, which was made clear by them.

5. The above misinterpretation of the position of the Kuen-lun Range was corrected by Chi-chau-nan (a great scholar of the present dynasty of China) in his "Shu-tao-ti-kang" (1800 A. D.), as the following will show:

The headwaters of the Hwang-ho, which are in the west of lake Odon-nor, are at the eastern foot of the Baian-Kara-ula Range and therefrom they flow, in a southeastern direction, under the name "Althan River." After uniting itself with the Chi-ken-chi and other rivers, the Althan empties its contents into the Odon-nor. The distance between the source of the Hwang-ho and the Odon-nor is measured to be more than 300 li [90 miles]. The Baian-kara-ula Mountains are the mountains which have from very ancient times been known as the Kuen-lun Mountains, and this range extending eastward from the Li-shi Mountains which contain the fountain head of the Chin-sha-chiang [the name given to the upper course of the Yang-tze-kiang] here forms a very high and complicated convolution; and therefore if we compare it with other neighboring mountains it appears like a father surrounded by his children. The fountain head of the Hwang-ho is at the points north latitude 35° and west longitude from Pe-ching [Peking] 20°, viz, east longitude 96° 29′. The Balan-kara-ula Mountains are known as Tsz-shan [the purple mountains] by the natives, which must have been so called from the color of the rock, because it is of a bright purple color, and so it is known, too, by the name of Kal-kon, which is nothing but a mere corruption of the name "Kuen-lun." Formerly General Tu-shi explored this region in order to discover the headwaters of the Hwang-ho; but his footsteps being confined to the valley where the Odon-nor glitters, he never touched the source of the river; and therefore, as a necessary consequence, he mistook the real position of the Kuen-lun Mountains. * * *

The Hwang-ho, after leaving the Odon-nor, passes through the two lakes Charing and Oring, as General Tu-shi has reported, and hence taking a northeasterly direction, then southerly, and lastly a southeasterly for a distance of more than 1,000 li [30 miles], it arrives at the foot of the great snowy Amreh-machin-mus Range, along the southern side of which the river is running eastward. This snowy range is that which was called "Tsi-shi-shan" in the ancient geographical books, and mistaken by General Tu-shi for the Kuen-lun Range. We have a very old tradition about the mountains which states that the Hwang-ho runs in a semicircular course round the mountains, and that tradition perhaps induced the general to take the Amreh-machin-mus Range for the Kuen-lun Range.

Now, comparing the description just quoted with the Carte de l'Asie Centrale, we find that the Althan River corresponds to the river which, coming from the Oulantechi Mountains, empties its contents into Lake Charing-nor; and that Chi-ken-chi River corresponds to that which, coming from the Chon-gon Range, joins the

Althan River, under the name of Soloma-zol River. The latitude and longitude of the fountain head of the Hwang-ho as given above do not exactly coincide with the carte; but as we have no means of correcting these differences, we must leave them till we shall learn the result of more complete surveys.

CONCLUSION

Our final conclusion of the present subject is very simple.

The Kuen-lun Range is not in the region which was pointed out in those passages of the works quoted in the beginning of this paper—that is, not in the Tsung-ling Range itself, nor in the southeastern part of it, nor in the mountains south of the town of Khotan—but it must be identical with the present Baian-kara-ula Range, or at least the mountains near it. Now, if this is fortunately acknowledged by scholars, then it would not be too much for us, we believe, to ask for the correction of the location of the mountains on the maps and geographical books which are circulating in the western world. But, if the conclusion first given were not fit to be adopted, our only alternative view is this:

The name "Kuen-lun" should be entirely excluded from the maps of the present day, because the name was once used to indicate a mountain range standing in the northwestern part of China, but many centuries later another name was substituted for it; and therefore it will be reasonable to keep the name in the history of geography only as that of a lost mountain range.

GEOGRAPHICAL WORK OF THE NEW JERSEY GEOLOGICAL SURVEY

By HENRY B. KÜMMEL, Trenton, N. J.

The fact that New Jersey was the first State to commence and carry to completion a systematic topographic survey of its territory, about twenty years ago, and the further fact that the State survey is now issuing a series of topographical maps on a much larger scale than any maps issued by any other State survey or even by the national survey, is my justification for the presentation of the following statements.

The present Geological Survey of New Jersey was established in 1864, but ten years before this there was an earlier organization, known as the Kitchell survey, which was discontinued after three years of work. Trigonometrical and topographical surveys were carried on during these three years, but the results were partially lost when the survey was abandoned.

FIRST TOPOGRAPHICAL SURVEY

During 1872–1875 topographical surveys, under the direction of Dr. G. H. Cook, then State geologist, were commenced in the iron districts of the State in Morris County and the great clay district in Middlesex County; but it did not seem possible at that early day to enter upon the systematic mapping of the entire State. In 1877 however, it was determined to construct a topographical map of the metropolitan district adjoining New York City, and two years later, in 1879, plans were announced for extending it over all the Highland district in which the important iron mines were located.

It is evident that this policy met the approval of the people of the State, for in the following year, 1880, the appropriation for the geological survey was continued by the legislature for five years more, in order that topographical maps might be made for the entire State. The work, however, was not completed in five years, but the appropriation was renewed in 1885 and the work was finished in 1887.

When the survey was about half done the State was able to take advantage of an offer of cooperation made by the United States Geological Survey, and thereafter the expense was in part borne by the national organization, although the work continued in the immediate charge of Mr. C. C. Vermeule, topographer, under Doctor Cook, the State geologist.

A correct estimate of the accuracy of any survey can be formed only by use of the maps in the field, but a brief statement of the methods followed and the degree of control by absolute measurements exercised over the topographical sketching will indicate approximately the accuracy of this work.

Primarily the control of this work rests on a triangulation by the United States Coast and Geodetic Survey, filled out and extended by the topographers so as to include a total of 458 stations, determined with what we may consider absolute accuracy. These stations are very close along the seacoast and large rivers, but in the interior they average one to each 25 square miles and are about 5 miles apart. The next step in securing measured control is the running of traverse lines over the whole area at an average of 2.53 miles of traverse to each square mile of territory, which is equivalent to a rectangular network with squares having sides of four-fifths of a mile. In important districts the lines are closer; in flat, level, and unimportant sections they are farther apart. The distribution of the highways being suitable for the purpose, they have been mainly followed in traversing, for convenience, the work being done with facility and suitable accuracy with a barrow odometer. A transit and stadia were sometimes substituted when the other method was inapplicable. From this network of traverse lines, which were closely connected with and adjusted to the triangulation, all important points of topography were located by traversing with a prismatic compass and pacing, these paced lines being checked out on a main traverse line opposite to the one from which the start was made. All streams of importance were followed in this way, and all summits and ridge lines were thus visited, studied, and located. It has been found that an experienced topographer can by such means secure good location and results as accurate generally as the scale can exhibit. Topographers have averaged over 4 miles of walking to each square mile of sketching, thus studying and representing all topography at short range. The bays, creeks, and marshes of the coast, as well as important rivers, were surveyed with transit and stadia. Heights have been determined almost entirely by the spirit level. A network of primary levels formed the basis for this work, the levels for topography being run rapidly with a light engineer's level. Elevations may be relied on to the nearest foot.[a]

For each square mile of territory an average of 1.97 miles of levels were run and 10.2 stations established, only a small proportion of which, however, were permanently marked in the field.

The field work was done on a scale of 3 inches to a mile, $\frac{1}{21120}$, and the maps were engraved and published on a scale of 1 inch per mile, $\frac{1}{63360}$. In the more hilly portion of the State the contour interval is 20 feet and in the regions of low relief 10 feet.

[a] Vermeule, C. C., Annual Report of the State Geologist for 1887, p. 16.

The entire cost of this work, exclusive of the primary triangulation by the United States Coast and Geodetic Survey but including tertiary triangulation over about 2,000 square miles, was $54,744.58, or $6.93 per square mile.

PUBLICATION

Manuscript maps were prepared on a scale of 3 miles per inch, but for publication they were engraved on stone on a scale of 1 inch per mile. Inasmuch as New Jersey is of irregular outline, and since the zones of exposure of the geological formations trend from northeast to southwest and the State can be divided into several distinct topographical districts, in publication the separate sheets were so arranged that no one of them should extend far beyond the boundaries of the State, that each important municipality should be well within the margin of some sheet, and that those maps which covered the same geological formation could be easily grouped. Under this arrangement the sheets overlap somewhat, and while it has certain advantages, yet it is a distinct disadvantage when several sheets are combined. Consequently, at the present time, as new editions are required, a new arrangement of nonoverlapping sheets is gradually being substituted.

Each sheet measures about 27 by 37 inches. The culture is in black, contours are in brown, water is in blue, and a basal yellow tint is printed over the entire sheet. Forested tracts are also indicated by a faint black pattern, but isolated houses are omitted.

SECOND TOPOGRAPHICAL SURVEY

The earlier topographical survey was completed in 1887 and the maps were published at once. In 1898 the State Geological Survey commenced the preparation of another series of maps on a much larger scale, designed to cover the more densely populated districts and to serve as a base for detailed geological work. In large measure the earlier work formed a basis for the later surveys. The original 3-inch per mile sheets were used as a foundation, and all new roads, trolley lines, street names, cemeteries, parks, sand, gravel, and clay pits, quarries, mines, etc., were added. In the few instances where field use showed that the topographical sketching could be improved, the necessary changes were made. Along the coast the shifting sand on the beaches and the tidal currents have in places so changed the shore line in fifteen years that entirely new surveys have been required in order to bring the maps up to date.

In order to avoid the heavy expense of engraving these maps on stone, they are printed by photolithography, in black, blue, and

brown, on a scale of 2,000 feet per inch, or about 2½ inches per mile. Each sheet measures 26 by 34 inches, and 18 have been published so far. Three more are in course of preparation.

SPECIAL MAPS

From time to time special surveys have been made of small areas to illustrate peculiar and striking types of topography. For these a scale of from 200 to 800 feet per inch has been adopted, with a contour interval of 5 feet. A portion of the great terminal moraine, a typical kame area, and a glacial delta have thus been mapped. The surficial geology has been represented on these maps, which were published in connection with a final report upon the glacial deposits, but in publication the scale was somewhat reduced.

RELIEF MODELS

As a further aid in the representation of the topography of New Jersey, a copper relief model of the whole State on a scale of 1 inch to the mile was constructed for the Columbian Exposition at Chicago in 1893. Later a photo-relief map, based on photographs of this model and lithographed on stone, was published on a scale of 4 miles per inch and widely distributed. Several other large scale plaster relief models of type areas have also been made for exhibition purposes.

CLIMATIC AND MAGNETIC STUDIES

From the first the State Geological Survey has recognized the fact that its field of work was not limited by hard and fast boundaries, but that some phases of work which were not geological were nevertheless a legitimate part of its field. Accordingly we find in the Geology of New Jersey, published in 1868 by Doctor Cook, tables of meteorolgical data, compiled from various sources, summarizing the existing knowledge regarding the climate of the State. These were supplemented by tables in later reports, and in 1889 a comprehensive and careful description of the climate of the State was prepared by Dr. J. C. Smock and published in Volume I of the Final Reports. In later years, with the establishment in the State of many stations of the United States Weather Bureau, manned by either volunteer or paid observers, the survey has relinquished its meteorological work.

MAGNETIC SURVEYS

During the progress of the topographical survey, 1877–1887, it was noticed that the distribution of magnetic declination was much more irregular that had been supposed, and that even when local

attraction was eliminated variations of one or two degrees prevailed over quite extended areas. Accordingly two parties were put in the field in October, 1887, for the purpose of making a large number of observations within a brief time, that our knowledge of the facts of magnetic distribution might be increased. I can not here take time to give in detail the results of these surveys, but must content myself with the statement that apart from the purely local attraction, like that near bodies of magnetic iron ore, a close relationship was demonstrated to exist between geological structure and magnetic distribution; that the principal irregularities occur in the vicinity of outcrops of gneissic rocks; that the trap rocks may cause equally great disturbances, and that disturbances due to either kind of rock are not confined to the actual outcrop but seem to be felt at stations 2 miles or more distant. The details of this survey were published in Volume I, Topography, Magnetism, and Climate.

REPORTS ON TOPOGRAPHY AND PHYSICAL GEOGRAPHY

A statement of the geographical work of the survey would be incomplete without a reference to two volumes of reports issued in 1889 and 1895, respectively. The first (Volume I) was a comprehensive report upon the geography, topography, and bench marks, together with a history of the various commissions which have from time to time fixed the territorial boundaries of the State. It was chiefly the work of Mr. Vermeule, who had conducted the topographical survey. The second (Volume IV) was a discussion, by Prof. R. D. Salisbury, of the topography from the view point of its origin and development. In this report the earlier and briefer studies of Prof. William M. Davis[a] were supplemented by much detailed field work and the recognition of several additional stages in the development of the topography due to alternate periods of elevation accompanied and followed by erosion and subsidence resulting in sedimentation.

The former report has been in great demand, particularly among surveyors and engineers; the latter by many classes of people, notably students and teachers.

[a] National Geographic Magazine, Vol. II, pp. 81–110; Boston Soc. Nat. Hist. Proc., Vol. XXIV, pp. 365–423.

FIRST ASCENTS AND EXPLORATIONS IN THE CANADIAN ALPS

By HERSCHEL C. PARKER, New York City.

[Abstract.]

The paper gives a brief account of expeditions in the Canadian Alps made in 1897, 1899, and 1904, and includes short accounts of the first ascents, made by the writer, of the well-known peaks Mounts Lefroy, Dawson, Goodsir, Hungabee, Deltaform, and Biddle.

Several of the above-named peaks present some of the greatest difficulties yet encountered in alpine work in America. The paper is illustrated by numerous lantern slides from photographs, many of which were taken by the author either during the actual climbs or on the summits.

DISCUSSION

Mr. MATTHES stated that he considered it especially fortunate that Professor Parker's paper could be presented at this session, as it furnished a basis for a direct comparison between the Canadian Alps and the Rocky Mountains south of the Canadian boundary. Even though Professor Parker's paper was intended to treat the subject from the mountain climber's point of view rather than from the scientist's, it was valuable to students of glaciology because of its very fine illustrations of the glacial sculpture characteristic of the Canadian Alps.

Professor COLEMAN expressed his admiration for the magnificent lantern slides of mountain scenery in the Canadian Rockies, especially in the neighborhood of the great Columbia ice field, and congratulated Mr. Parker on the admirable photographs and on the brilliant success of his mountaineering in that difficult region. Though not an expert mountain climber, he (Professor Coleman) and three companions could claim to have been the first party of white men to see the grand group of mountains surrounding the Columbia ice field, which they passed in 1892 on their way to Mount Brown. There was a fascination about the region which tempted one back to it again and again, and it was no wonder that Professor Parker, Professor Collie, and others had risked their lives to explore it.

RESULTS OF A JOURNEY AROUND MOUNT M'KINLEY

By FREDERICK A. COOK, Brooklyn, N. Y.

Mount McKinley is a new rival of the great peaks of the world. Though known to the Indians and the Russians for centuries, it was not until recently recognized as a great mountain. But aside from its giant proportions, the wonderful uplift is remarkable because of its position and the atmospheric peculiarities which it makes for much of mid-Alaska. Its slopes form a watershed for the Yukon, the Kuskokwim, and the Sushitna, Alaska's greatest rivers; its walls offer a barrier to the warm, humid airs of the Pacific as well as to the icy winds of the Arctic, and the elements thunder around it, making its surface a ceaseless battleground, and as such it is likely to be a striking landmark for all time.

The expedition to Mount McKinley, the results of which are here outlined, started from Seattle on the steamer *Santa Ana* on June 10, 1903. After a delightful voyage of two weeks among the beautiful coastal islands, the steamer put us ashore at Tyonek, Cook Inlet, Here we began the very difficult task of getting over a forbidding wilderness with our outfit.

There are three possible routes to Mount McKinley: (1) Southward from the Yukon, (2) northward up the Sushitna, and (3) over Simpson Pass, and thence along the westerly foothills of the Alaskan Range. We chose the latter route. With a light equipment packed on 14 horses we marched along the beach of Cook Inlet to the Beluga River, thence by an old Indian trail to the Skwentna River, and then over marshes to the Keechatna River. A boat was taken up the Sushitna and Yentna rivers to meet the pack train and ferry the men and packs. Following closely the old trail cut by Heron along the Keechatna, we crossed the range through Simpson Pass to the Kuskokwim. From this point we set a rather straight course along the north slopes, similar to that of Brooks, to the northwest base of Mount McKinley.

We pitched our camp on a branch of the Tatlathna River about 14 miles northwest of the peak of Mount McKinley. Here we made the preliminary arrangements for the first ascent. We had now marched

nearly 500 miles during forty-nine days. On the eastern side of the range we encountered many disheartening obstacles; progress through thick underbrush and over soft marshes was very slow and difficult. But along the westerly slopes the weather was good, the traveling easier, and large game was abundant. The men and horses were now in excellent training for the more difficult task before them. Near the mountain the weather was stormy and wet, but our plans were so arranged that climatic conditions did not seriously interfere with our movements.

Mount McKinley, as seen from the north and west, presents a stupendous sheen of granite cliffs and ice walls. The foothills rise out of an old glacial shelf at 4,000 feet elevation, and about 10 miles from the peak. The lower hills, which are rounded by glaciation, are quickly succeeded by a few pyramidal peaks which scrape the lower clouds at 6,000 feet. These foothills lead to Roosevelt Ridge, which extends along nearly the whole western face of the main mountain and is separated from it by Hanna Glacier. Ordinarily the clouds sweep the slopes from 6,000 to 12,000 feet, and thus blot out the upper line of Roosevelt Ridge and the huge gap made by Hanna Glacier between it and Mount McKinley, giving the great uplift the appearance of gradual easy slopes. But the cloudless skies of night and morning alter the prospect to one of sharp contours, interrupted arêtes, and successive cliffs of rock and ice. Roosevelt Ridge, which has an altitude of 8,000 feet at the northwest, gradually rises to 12,000 feet at the southwest. Its crests are blanketed by sheets of ice with huge cornices and overhanging glaciers to the west, and to the east many tributary glaciers carry ice from these ice sheets into Hanna Glacier. At this time we supposed that Roosevelt Ridge was continuous with the southwest arête, and accordingly we prepared to make an ascent in the most direct way possible.

Moving our horses and outfit into the foothills, we ascended over an old moraine into a new glacier which will bear the name of one of my companions, Shainwald Glacier. This glacier forms the floor of a great amphitheater at the southwest end of Roosevelt Ridge. Selecting a route over the least difficult slope, we ascended to an altitude of nearly 9,000 feet, and here discovered that we were barred from the main mountain by a deep gorge in which lay Hanna Glacier. Our only hope now was to descend and march over Hanna Glacier. Moving our entire camp 20 miles northwest, the next base camp was pitched close to the terminal moraine of Hanna Glacier. The lower 8 miles of this glacier was entirely covered by broken stones, so much so that traveling over it was impracticable; but we found a caribou trail to the north side of the glacier which led to the base of Mount McKinley. We next set a course over the icy surface of Hanna

Glacier to the southwest arête, rising out of the glacier from an altitude of 8,000 feet. We cut steps for 3,000 feet up a slope of 60 per cent under snow 14 inches deep. At 11,400 feet a spur interrupted our progress. Here a cliff of granite, whose crest was nearly 5,000 feet above us, effectually checked our climb. We had previously seen this, but had persuaded ourselves that we might find some way around the difficulty, but we found none, and were again forced to descend without reaching the summit, the goal of our ambition.

The weather was generally good, though clouds drifting against the mountain brought snow every day. As we ascended, the temperature steadily fell from 40° to 12°. The upper cloud level settled at night and rose during the day, ranging between 9,000 and 12,000 feet. The clouds seen from above resembled a rough sea flooded with a feeble golden light. In the southwest there appeared a series of wonderful peaks—first, Mount Foraker, a cross-ridged peak; then Mount Russell, a giant ice pyramid, swept, as is Mount McKinley, by lateral glaciers, and beyond, Mount Dall, a rocky pyramid. Between Mounts Dall and Russell we saw a new cluster of peaks to which we gave the name Bryant Peaks, in honor of the worthy chairman of this section, Mr. Henry G. Bryant.

In descending to the land of little trees we examined the northwest arête and the whole western face of the giant peak, but we found no other promising route. On September 4, with the frost and snow of the coming winter increasing, we were forced to seek a way out of the country. That we might get a better knowledge of Mount McKinley we chose a route across the Alaskan Range through the first pass northward. This route took us over unexplored country, and with our previous route made an important circuit, not only around Mount McKinley, but around the main group of the Alaskan Range.

After passing Muldrow Glacier, we set a course eastward behind the foothills to seek a pass. But a few hundred yards beyond this glacier and flowing parallel to it in a canyon we discovered a large glacial stream. Following this river we soon saw that it was the output of a number of small glaciers draining a cluster of seven sharp peaks about 9,000 feet high. To this river we gave the name LeConte River, and to the peaks the name Belgica Peaks. Then taking a northeasterly course we came into a broad glaciated valley running parallel to the range for 20 miles, but draining westward into the Tachlat. In this valley, at a point 46 miles northwest of Mount McKinley, we discovered a break through the range. Marching up a large glacial stream we ascended a new glacier and wandered across its rough surface in the face of a violent storm. The glacier we gave the name Harvey Glacier, and to the stream the name Dunecke

River. At an altitude of 6,000 feet we saw the low, tree-covered valley of the Chulitna. Descending to the eastern side of the range we found the climate warmer and more humid. After a day's march we located the main easterly tributary of the Chulitna, which starts from a number of glaciers about 36 miles north of Mount McKinley. To this river we gave the name Bridgman River, in honor of the secretary of the Peary Arctic Club.

Following Bridgman River we were led into a deep canyon, where we were compelled to abandon our horses and build rafts in which we drifted to the eastern foothills of Mount McKinley.

Mount McKinley, like most large mountains, presents a very different aspect from different points of view. From a mountain 35 miles northeast, looking across unnamed peaks 12,000 feet high, we got a striking view of the great McKinley uplift. An almost constant stream of clouds swept over and around the mountain from the east, and a blue electric glow softened the rough outline. Now and again we could see the summit, and from this point it resembled very much the crown of a molar tooth; four tubercles were distinctly visible—the saddles seen from the west formed two, and to the east were two rather higher and more distinct. These tubercles of this giant tooth are separated by large glaciers whose frozen currents pour down very steep slopes into Fidele Glacier. Apparently continuous with Mount McKinley and extending northeastward far beyond our position, there was a sharp, icy ridge, in which we saw several mountains over 10,000 feet high.

From the east and south the great peak resembles somewhat a beehive, and it appears rather larger than from the west and north, but the approaches from this side are still unexplored. Two very large glaciers drain the eastern slopes: Fidele Glacier, probably the largest of interior Alaska, receives the output of several small glaciers about the northern and eastern slopes, and then, after taking a northeastern coarse, it is joined by two large glaciers, beyond which it circles among unknown mountains to the Chulitna River, where its face is 8 miles wide. Ruth Glacier, a somewhat smaller stream, begins among the amphitheaters about the southeastern slopes, and taking a tributary from Mount Foraker and others from the lesser mountains eastward it describes a semicircular course southward to the Chulitna River. Between these two glaciers there is a wide belt of sharp mountains from 5,000 to 12,000 feet high, separated by deep canyons.

Mount McKinley offers a unique challenge to mountaineers, but its ascent will prove a prodigious task. It is the loftiest mountain in North America, the steepest mountain in the world, and the most arctic of all great mountains. Its slopes are weighted down with all

the snow and ice that can possibly find a resting place, but, unlike that of Mount St. Elias, its glaciation is not such as to offer a route over continuous ice. It lies far inland, in the heart of a most rugged and trackless country, making the transportation of men and supplies a very arduous task. The thick underbrush, the endless marshes, and the myriads of vicious mosquitoes bring to the traveler the troubles of the Tropics. The necessity for fording and swimming icy streams, the almost perpetual cold rains, the camps in high altitudes on glaciers in snows and violent storms bring to the traveler all of the discomforts of the Arctics. The very difficult slopes, combined with high altitude effects, add the troubles of the worst alpine climbs. The prospective conqueror of America's culminating peak will be amply rewarded, but he must be prepared to withstand the tortures of the torrids, the discomforts of the north-pole seeker, and the hardships of the Matterhorn ascents multiplied many times.

THE EXPLORATION OF ALASKA

By A. H. BROOKS, U. S. Geological Survey

[Abstract.]

The first knowledge of Alaska was obtained by the Russians, who in the early part of the eighteenth century had established themselves on the western shore of Bering Sea, and first learned of the continent beyond the sea from the natives, or it was not until 1741 that they obtained any definite knowledge of northwestern America by personal observation. It was then that Bering made his fateful voyage and definitely established at least one point on the mainland of Alaska. Subsequent exploration appears to have taken place from three directions. The Russians came from the west, across Siberia, Bering Sea and Strait; the English from the East, by way of Mackenzie Valley; and navigators of various nationalities explored the coast, approaching from the south, by following the eastern shore of the Pacific. Among the important expeditions were those led by Bering, Lütke, Kotzebue, Cook, Vancouver, Franklin, Beechey, Malaspina, La Pérouse, and several Spaniards. By the middle of the eighteenth century the coast line of Alaska was fairly well known, but the detailed charting has not even yet been completed, though the United States Coast Survey has been actively at work for many years. Of the interior of Alaska the Russians knew comparatively little, though they explored the lower stretches of the Yukon, the Kuskokwim, and Stikine. The upper Yukon was reached by the Hudson Bay traders in the middle of the nineteenth century.

In 1865 the exploration of Alaska was much accelerated by the work of the corps of explorers organized by the Western Union Telegraph Company, of whom William H. Dall and Robert Kennicott were the most prominent.

When Alaska came into the possession of the United States but little attempt was made to explore its interior, though a few expeditions were sent out under various auspices. Thus it was that Schwatka made an exploration of the Lewes and Yukon rivers,

though these were already pretty well known, thanks to the traders and prospectors. Allen traversed the Copper, Tanana, and lower Koyukuk rivers, while Stoney took up the exploration of the Kotzebue Sound region, and in the same district Cantwell and McLannigan made important explorations.

Though public enterprise amounted to little, yet the ever-ready American frontiersman and prospector penetrated this wilderness and did much in making it known to the world. Among the most prominent were Frank Densmore, Arthur Harper, Jack McQuestin, and Jack Dalton.

In 1891 the Coast Survey was represented in the interior in Alaska by parties which located the international boundary and made an exploration through to the Arctic coast from the Yukon drainage basin. During the same period Schwatka and Hayes made a journey of exploration from the Yukon to the Copper by way of the head of the White.

It was not, however, until the discovery of the famous Klondike gold fields that Congress awoke to the necessity of systematic explorations and surveys of this great area. Appropriations for this purpose were made in 1898, and have been continued up to the present time. Much of the interior of Alaska has been explored by numerous parties of the United States Geological Survey. These have covered an area of approximately 100,000 square miles, and now practically every large river in the territory except the Noatak, Colville, and Alsek has been surveyed. All of the mountain ranges except those of the extreme northern part of the territory have been outlined by exploratory surveys, and much of the great interior basin has been mapped with a sufficient degree of accuracy for present purposes.

Of unknown regions there are in Alaska only three of considerable extent. The smallest of these embraces the great snow-covered St. Elias Range, which, though but a short distance from tide water, is so inaccessible that little is known of its geography or geology. A second unexplored area lies adjacent to the Arctic coast and the international boundary, and extends southward into the Yukon basin, embracing about 40,000 square miles that are practically unknown. A third unexplored area lies in the northwestern part of the territory west of the one hundred and fifty-first meridian and north of the sixty-eighth parallel. This also includes about 40,000 square miles, and is almost entirely unknown, though Schrader and Howard have traversed its eastern margin. Of little-known areas we have also the Kuskokwim basin, which probably embraces some 15,000 square miles, less than half of which have been surveyed.

THE PHYSICAL GEOGRAPHY OF MEXICO—AN INTRODUCTION TO THE SOCIAL, POLITICAL, AND ECONOMIC GEOGRAPHY OF THE REPUBLIC

By ROBERT T. HILL, New York City

[Abstract.]

In this paper the physical features of Mexico are classified and their relationship to the North American Cordilleran region to the north and the Antillean region to the south is defined.

The country is divided into four distinct geographic provinces, to wit: The Sonoran, the plateau (or Chihuahuan) province, the Gulf coast plain, and the Isthmian province.

Of these the plateau province embraces nine-tenths the area of the Republic, and is its chief physical feature, to which the other provinces are subordinate. The plateau province is shown to be the southern continuation and termination of the great North American Cordilleran system. Its relations, however, are not with the Pacific mountains or the Rocky Mountain ranges, but with the Colorado Plateau, from which it was evolved by the folding and faulting of the latter toward the south, and in common with the Colorado Plateau, it has been subjected to great epierogenic uplift and subsidence.

This plateau in Mexico is surrounded by fringed escarpments whose erosion and faulting record its physiographic history. The eastern scarp is the edge of the anticlinorium of folded strata constituting the mass of the plateau; the western edge, now receding eastward by erosion, is the vast fault scarp upon the downthrown side of which is the Sonoran, or Pacific, province. The southern end of the plateau abruptly terminates at the Pacific Ocean, and is probably caused by faulting accompanying the east-west strikes of the later orogenic movements in the Antillean region, which here directly crosses the northwest-southeast strikes of the Cordilleran system.

The summit of the plateau is classified into eminences and depressions—the products of faulting, volcanic piles, and erosion—the

variations of which constitute the configuration of the sierras and bolson deserts of the Republic.

It is shown that most of the great recent volcanic piles rise from the summit of the degraded plateau, the higher remnantal summits of the higher mountains of which in Arizona, New Mexico, trans-Pecos Texas, and Mexico are from 8,000 to 9,000 feet above the sea. The eastern Sierra Madres are the survival of the harder material of the anticlinal folds; the western Sierra Madres are destructional forms resulting from erosion of the scarps of the former fault line. The great Sierra Madre del Sur, south of the Balsas, hitherto considered an independent orogenic feature, is shown to be a dissected remnant of the plateau, now disconnected from the parent body by the deep erosion of the Rio Balsas.

These features, with the drainage, are described in order to bring out more clearly in a later paper the bases of the cultural geography, especially their relation, through climatic effects, to agriculture and forestry, and through geological structure to mining, and their topographic influence upon transportation, distribution of population, and future development.

DISCUSSION

Professor Heilprin expressed the hope that Mr. Hill's prediction that Mexico might soon become a part of the United States might not be verified, expressing his feeling that the Republic's distinctive national characteristics should be perpetuated, pronouncing Mexico one of the most attractive sections of the continent, and of exceptional fertility.

THE EVERGLADES OF FLORIDA

By Rev. JOHN N. MACGONIGLE, D. D., St. Augustine, Fla

The object of this paper is to state, within the least possible limit, what is known of the Everglades of Florida to date, the facts stated having been gathered from reports of various explorations during the past sixty years and from personal observations made at various times during the past eight years.

The area under discussion is unique in the history of exploration, for although it was known to the earliest Spanish explorers, it remains practically unexplored to this day.

Located in the extreme southern portion of the peninsula of Florida, the Everglades extend north and south about 130 miles and east and west about 70 miles. While no survey of any nature has been made, it may safely be said that the proportions of land and water in the area are about 1 to 20. Occupying the position it does in the peninsula of Florida, the area brings to our consideration the continental relation of the peninsula as furnishing a clew to the origin of the Everglades and their peculiar formation. This continental relation is of course determined geologically. Running through the entire length of the peninsula is one massive formation, which occasionally outcrops, but is generally overlain by a mantle of sand. This formation has long been identified as the Vicksburg limestone of the Eocene period. It is an important member of the Laramie group, and, coupled with the general trend of the peninsula, shows that its continental relation is not with the Appalachian system, as would be supposed, but with the system of the Cordilleras. This Eocene limestone forms the backbone of the Florida peninsula, which is really a mountain top whose final emergence from the sea left it with its present covering of sand.

The most striking characteristics of this formation in Florida are its almost numberless lakes, many of which show subterranean connection with one another; its great springs, like Silver, De Leon, Blue Springs, and numerous others; and its well-known subterranean pools and streams tapped by artesian borings and yielding water of

arrowroot, grows wild, taking the place of both starch and flour in the Seminole's diet. Here a new and unstudied area of the greatest interest awaits the botanist. When the Seminole tills the land he raises all the vegetables of the temperate and subtropical regions with slight labor.

Bear, deer, and panther are still found. Otters, which are very abundant, are the chief source of the Seminole's income. Alligators are found in large numbers, and in the mangrove swamps on the southeastern edge the crocodile (*C. americanus*) is occasionally met with. Venomous snakes, particularly the rattlesnake and moccasin. are so numerous as to make exploring very uncomfortable and dangerous, and this is particularly true of the western edge.

Ducks, egrets, and the large waders abound. The limpkin (*Arameus giganteus*), like an overgrown snipe, a brown duck about the size of the brant, and the Everglades kite are characteristic species.

Fresh-water fishes are found in fair quantities. The Everglades terrapin and a soft-shell turtle, found only here, both edible, are abundant. Owing to the constantly moving water and singularly pure air, the interior of the Glades is unusually free from insect life.

Many of the islands have been inhabited, at intervals, for centuries. Mr. Buckingham Smith, who studied some of them in 1847, says, however, that "there is no evidence that the inhabitants at any time were other than Indians." The area has been for over seventy years the peculiar possession of the Seminoles, and it will probably remain so.

The project of draining the Everglades has frequently been considered with a view to reclaiming the incalculably rich muck lands; but almost equally rich lands are already available on the coastal plain, and the unknown quantity which the subterranean supply suggests is a deterring factor.

The climate of the Glades is most mild and equable. The vegetation shows by its habit of growth that frost is unknown. Only moderately high temperatures prevail in summer and these are much modified by the prevailing breezes. The year divides naturally into the dry and the rainy season, the latter continuing from June 15 to September 15, approximately, the rainfall reaching a [illegible]imum of 10 inches per month. [illegible] the heart of the Glades, [illegible]er, light showers are common a[illegible]son of the year.

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Ingraham, in 1892. The Seminole, however, finds no difficulty in crossing at his pleasure. Doubtless he is aware of secret paths which, for wise reasons, he reserves for himself.

The water in the Glades is always pure and clear and drinkable. Nowhere is it stagnant; nowhere does it seem to be wholly at rest. It seems to move in one mass from the northeast toward the south and southwest, as though it were passing from one central source, which we know is not the case, to its several outlets. To be sure, this moving mass of water is intersected by numerous currents and countercurrents. These make their way through the saw grass, usually ending in a closed pocket, greatly increasing the explorer's difficulty. These currents no doubt are due to the inflow and outflow of water by subterranean channels. Two sources are conceivable for the supply of water, namely, precipitation and, as I stated to the National Geographic Society in 1896, subterranean springs and streams. The rainy season, covering June 15 to September 15, with a maximum monthly rainfall of 10 inches, will not account for all the water present. The subterranean supply is not only presumed to exist, it is actually present. Numerous observers have noted the presence of huge springs. Lieutenant Willoughby passed over many such during his exploring trip in 1897.

From the character of the formation to which the Everglades basin belongs, as already pointed out, it is quite clear that the greater portion of the pure, limpid water of the Glades comes from springs of great volume. It will be borne in mind also that no area whatever drains into the Everglades. At all seasons they are drained by such rivers as the Miami, New River, and others emptying into Biscayne Bay; by the Harney, the Shark, and others emptying into White Water Bay and the Gulf of Mexico; and during very high water the overflow crosses the rim on the north, pouring into Lake Okeechobee. The Glades rivers, it may be said, have worn their way through the rocky rim.

The area under discussion, therefore, is not a swamp or a marsh, as popularly supposed, but a massive rock basin which is filled with pure water that is in constant motion but which is given a marshy appearance by the ever-present saw grass, and which somewhat resembles a swamp, also, on its edges, owing to the characteristic growths of cypress and cocoa palm.

The islands of the Everglades are covered, where untilled, by a magnificent growth of timber and vines. The live oak, the bay, wild lemon, wild orange, and custard apple abound, and the rubber tree, palmetto, and pine are not wanting. Wild fig, the wild morning-glory, and myrtle grow in great masses and lilies and orchids in tropical profusion. On the dry lands the coontie, or Florida

arrowroot, grows wild, taking the place of both starch and flour in the Seminole's diet. Here a new and unstudied area of the greatest interest awaits the botanist. When the Seminole tills the land he raises all the vegetables of the temperate and subtropical regions with slight labor.

Bear, deer, and panther are still found. Otters, which are very abundant, are the chief source of the Seminole's income. Alligators are found in large numbers, and in the mangrove swamps on the southeastern edge the crocodile (*C. americanus*) is occasionally met with. Venomous snakes, particularly the rattlesnake and moccasin, are so numerous as to make exploring very uncomfortable and dangerous, and this is particularly true of the western edge.

Ducks, egrets, and the large waders abound. The limpkin (*Arameus giganteus*), like an overgrown snipe, a brown duck about the size of the brant, and the Everglades kite are characteristic species.

Fresh-water fishes are found in fair quantities. The Everglades terrapin and a soft-shell turtle, found only here, both edible, are abundant. Owing to the constantly moving water and singularly pure air, the interior of the Glades is unusually free from insect life.

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One interesting phase in the climatology of the Glades is their marked effect on the climate of the coastal plain to the east. This coastal plain in itself presents an entirely new phase in the geography of the peninsula. It is composed of a very recent formation of marine limestone laid on the edge of the Everglades outcrop and intersected by the Glades rivers and great stretches of open prairie. Owing to the conditions on the coastal plain and the influence of the Everglades to the west and northwest, the climate and productiveness

of this area are not surpassed in the world, presenting conditions in both winter and summer in which the maximum results of labor are procured by the minimum of effort.

DISCUSSION

Professor HEILPRIN, remarking that he spoke from personal observation, suggested that important sources of the water supply of the Everglades were Kissimmee River, Fisheating Creek, etc., and that Lake Okeechobee acted as regulator.

He was inclined to place the geological formation of the shores of the Everglades as late as the post-Pliocene, regarded the cypress swamps as unique in vegetation, and said that only a few years ago the birds of the Lake Okeechobee region were so numerous as to recall the " clouds " of birds in the Arctic regions.

GEOGRAPHY OF THE PAN-AMERICAN RAILWAY

By CHARLES M. PEPPER, United States Commissioner

In presenting this account of the projected Pan-American railway let me explain first the political geography of the region to be traversed. The project is not the conception of a single government. It is an undertaking which can be made feasible only by the cooperation of a dozen or more countries. The United States has its lines extended to Mexico; Mexico has carried its railway system across the Isthmus of Tehuantepec and will reach the northern border of Guatemala within three years under an existing concession; the Argentine Republic is prolonging its railroads northward into Bolivia. Each government acts within its own limits, but Argentina, under an international treaty, also carries its line into Bolivian territory as far as Tupiza.

The countries of Central America, and Colombia, Ecuador, Peru, and Bolivia, have yet before them the problem of extending their railway systems north and south, so that ultimately they may join with one another and the through trunk line be completed. The questions of political geography therefore concern the independent entities known as the various nations. What was sought by the first Pan-American conference in Washington and by the second conference in Mexico was to secure the necessary international cooperation. The task in hand is much more difficult than that of building a railroad, under a single government, from Patagonia to Alaska.

It is a grand idea, which appeals to the imagination, but practical results have to be secured in a practical manner. Local traffic, national policy, and strategic reasons are the mainsprings of governmental action. The principal result of the two Pan-American conferences has been the creation of the permanent Pan-American Railway committee. The chairman of this committee is the Hon. Henry G. Davis, who occupies a prominent position in the public affairs of the United States. Mr. Andrew Carnegie is a member, and the other members are the ambassador from Mexico, the ministers

from Peru and Guatemala, respectively, and the writer. Here, then, is the political geography of the project—simply international co-operation toward a specific end.

A steel highway which will unite all the Americas undoubtedly will be one of the longest continuous railway lines that the geography of the globe admits, for the stretch from Alaska to Patagonia should always be kept in mind. Ordinarily New York and Buenos Ayres are taken as terminal points, but Hudson Bay and Patagonia might just as well be selected. However, from New York to Buenos Ayres the land route is between 10,000 and 10,500 miles. The length of the trans-Siberian road is given, roughly, at 6,000 miles. When the present war in the Orient is ended, no question exists that Peking will be placed in railway connection with the trans-Siberian road. Then the distance by rail from Paris to Peking will be 7,622 miles. The road from the Cape to Cairo, the dream of Cecil Rhodes, involves crossing 65 degrees of latitude. The Pan-American project from New York to Buenos Ayres alone will involve 75 degrees. The Cape to Cairo route, including rail and water transport, is now open from Cape Town to Victoria Falls on the Zambesi, a distance of 1,633 miles. It is no longer considered without reference to the water links. This route is entirely inland, with no outlet to the seaports. The Pan-American project is based largely on branches reaching the seaports. That is a difference worth noting in the comparisons of prospective traffic.

Actually, links in the Pan-American trunk line for which as yet no definite provision may be said to be made do not aggregate more than 3,000 miles. My reason for stating this is that construction now going on and construction which is assured in the various countries during the next few years make Guatemala City the northern terminus and Cuzco, in Peru, the southern terminus, as I shall explain more in detail. Between these two distant points some disconnected lines are already built. The distance from Ayutla, on the southern border of Mexico, to Rio Golfito, on the border of the Republic of Panama, is 1,043 miles, and from Golfito to the Canal Zone or the city of Panama is 334 miles. This is over the route located by the intercontinental survey in 1896. Of this 1,337 miles about 370 are in operation. From the Panama Canal Zone across Colombia to the Carchi River in Ecuador is 1,020 miles. From the Carchi across Ecuador to the river Canchis near the border of Peru is 658 miles; and from this point to Cuzco is 1,531 miles. The recently completed Cerro de Pasco railroad in Peru subtracts 86 miles of this total. We have then of the intercontinental location approximately a distance of 3,526 miles between Ayutla and Cuzco, on which there are 457 miles of railway in operation and 3,069 miles to be undertaken. In this

calculation I have eliminated the Argentine prolongation, the entire Bolivian section, and a short section between Cuzco and Sicuani in Peru, because measures to which the various governments are committed insure the building of those links within the next few years. The uncovered distance—that is, the links for which no definite provision has been made, is less by, say, 300 miles than the transcontinental routes from New York to San Francisco, and greater by 100 miles than from Montreal to Vancouver over the Canadian Pacific route, which is 2,900 miles.

It is also less by 500 miles than the route to be covered in the latest great railway enterprise which the Dominion of Canada has entered upon in partnership with a private corporation. This is the Grand Trunk Pacific, which is to run from Monkton, New Brunswick, on the Atlantic, to Port Simpson or Butte Inlet on the Pacific, with a branch to Dawson in the Klondike region. The distance from Monkton to Port Simpson is 3,554 miles, and the estimated cost of this line is $100,000,000. Topographically there is little similarity, as by the Port Simpson route the highest pass in the mountains does not exceed 2,000 feet, while in the intercontinental location there are passes ranging from 12,000 to 15,000 feet which must be crossed. Yet from Monkton to Winnipeg is a stretch of 1,600 or 1,800 miles in which the local traffic may afford less returns than are to be had over some sections of the Pan-American. I refer to this merely as an illustration on the commercial and industrial side. In the sense of political geography there is, of course, no comparison, because the Dominion of Canada is able of itself to do what must be done in combination by ten or twelve Central and South American nations.

The intercontinental survey made during 1893 and subsequent years, gives the full tracings of a possible railway line from the border of Mexico to Lake Titicaca. Though modestly described by Chief Engineer Shunk and his associates as an engineering reconnaissance, in reality it was much more than that. These tentative surveys and locations need only be outlined, because they are available with the maps and descriptive information that have been published.

Let me take, first, the route from the southern border of Mexico to the Panama Canal Zone. It nearly parallels the continental divide that separates the Atlantic from the Pacific and follows closely the Pacific slope in the general direction from west-northwest to east-southeast. In other words, it is a coast route, crossing the slender spurs which shoot out from the divide. For reasons of commercial geography, always important in railway construction, the location trends along the lower edge of the coffee belt in Guatemala and follows the water courses through Salvador and Honduras and across Nicaragua. The engineering obstacles are not very serious until the central belt, or about latitude 10°, in Costa Rica is reached.

Costa Rica now has an interoceanic line from the Atlantic at Port Limon to Punta Arenas on the Pacific, in which the gap is only 15 miles. The suggestion has been made that the intercontinental route might be varied here, and the Atlantic slope taken from near Port Limon to Boca del Toro, in Panama, and then across to the Canal Zone, which is traversed by the Panama Railway. Agricultural and commercial considerations give force to this suggestion, for the banana and other fruit industries on the Atlantic slope are already securing additional railway facilities, and it would not be difficult to link them together in one general enterprise. The engineering problems would be much simpler than to surmount the great barrancas and chasms between the spurs of the mountains in southeastern Costa Rica, which has to be done in order to reach David, the northwestern port of the Republic of Panama.

When the intercontinental survey was made this alternative route was suggested, but a detailed study was not attempted, and for that reason the line traced follows the Pacific coast to Panama. Yet the broad idea of the Pan-American project must inevitably take into consideration commercial and industrial development, and the line must zigzag, so that the political geography may vary in a considerable degree. It will not be at all surprising if the ultimate through-rail connection between Guatemala City and Panama partly avoids that portion of the Andes known as the "Serrania of Darien" in its northwest extension and seeks the Atlantic coast. The distance would be about the same as along the Pacific.

From Panama east and south the Serrania of Darien was followed in the intercontinental survey. The real engineering problem for the South American Continent which the survey sought to solve was to find the best route, as shown by the general direction of the water courses and the trend of the mountain masses. In Colombia the location branches from the Cordillera Oriental to the Central Cordillera and reaches the divide between the Cauca and the Magdalena valleys, where the peaks range from 12,000 to 16,000 feet in height. Then it follows the Western or Occidental Cordillera, which is part of the principal axis of the Andes west of the Cauca River, and here again the peaks are from 10,000 to 16,000 feet high.

The political division of Ecuador geographically has well-defined mountain systems instead of a jumble of mountain masses, and the general direction is north-northeast and south-southwest. The elevated region lying between the Oriental and the Occidental Cordilleras is connected by cross ranges or knots, and the engineering problem is to find suitable crossings from one depression to another, and avoid the steep spurs that jut out from the main Cordilleras and produce enormous chasms. The line extends from a point near Ipiales across

Ecuador to the river Canchis in a general direction south by west, and the distance is about 650 miles for railway location. The highest projecting spurs which have to be surmounted are those extending from Chimborazo, some of them 12,000 feet. In southern Ecuador is the Sabanilla Pass, 9,390 feet high, but the general route for a railway is not difficult since the water courses that form the outlet for the different basins empty into the river Marañon and afford natural routes. Moreover, the bulk of the Ecuadorian population is on this great central plateau. The line from the seacoast at Guayaquil, which is completed to Guamote and is projected to Quito, has one section that could form part of the intercontinental route. Commercial reasons and the lack of serious topographical difficulties make it possible that Quito may be joined with its next largest city, Cuenca, by rail. The distance is 247 miles.

In Peru the trend of the mountain masses is not so regular as in Ecuador. The Occidental Cordillera forks and the western spur approaches the intercontinental location through a knot or pass about 13,000 feet high. The continental divide takes a southerly direction past Cajamarca and then turns abruptly eastward near Huamachuco, where the pass is 12,280 feet. Thence it follows south by southeast to the Cerro de Pasco Range, which separates the tributaries of the Marañon from the tributaries of the Huaraz or Santa River. In the valley of the Marañon the towns lie west of the river but east of the continental divide. The general parallelism of the Marañon, the Huallaga, and the Ucayali rivers furnishes alternative routes in the Cerro de Pasco region. Cerro de Pasco, it must be remembered, though in the Ucayali Basin, is on the Atlantic slope. The continental divide west of Oroya has a southeasterly trend to Puquio, where it forks.

Taking Peru as a whole, a right line from the river Canchis, near Zumba, to Cerro de Pasco, would be south 25° east 444 miles; Cerro de Pasco to Cuzco, south 56° east 347 miles; Cuzco to Desaguadero, south 43° east 290 miles. The railway location, as given by Engineer Kelly, would cover a distance of 1,785 miles. The Cerro de Pasco Railway from Oroya now forms a link of 86 miles in the intercontinental route. From Oroya to Huancayo, along the valley of the Oroya River, is about 74 miles. The engineering difficulties begin a short distance beyond Huancayo and cover the entire region to Ayacucho and thence to Cuzco. From Cuzco to Sicuani the link of 87 miles is to be built within a short time if the present plans of the Peruvian Government are carried out. Then there will be a through railway line to Puno, on the borders of Lake Titicaca. The intercontinental survey, ignoring water transport, was projected along the Desaguadero into Bolivia, but the water link across Lake Titicaca to Guaqui would serve the purposes of through railway

transportation, as it would be a ferry similar to that from Grand Haven to Milwaukee, or across Lake Baikal in the trans-Siberian route. The difference, however, would be that Lake Titicaca is always open to navigation and ice breaking is unnecessary.

I have outlined the intercontinental survey thus far because a summary of it has the scientific value which could not attach to the unscientific observations of a layman. But as the survey did not extend into Bolivia and Northern Argentina, I shall give my own observations of those regions, and I shall begin at the Argentina end. The existing system of the Argentine railways extends ever the pampas and into the gently rising sierras to Jujuy, 4,000 feet above sea level, a thousand miles northwest of Buenos Ayres. The railway and engineering question is to prolong the existing lines through the territory of the two countries until Lake Titicaca is reached. My own notes were made in taking the old Spanish trail over a distance of 350 miles and traveling by mules and on foot.

There are two routes from northern Argentina into Bolivia. One is from Salta, through what is known as the quebrada or great ravine of Toro, and the other from Jujuy through the great ravine of Humahuaca. A considerable commerce by means of mules, llamas, and burros is carried on by both routes, but the heaviest amount goes through Humahuaca. The larger part of the European merchandise for the cities of Bolivia takes that course. The Toro trail makes it necessary to traverse the higher peaks and is disliked by the freighters on account of the intense cold and the snow and also because there is practically no population. After an engineering controversy the Government decided on the Humahuaca route, following the course of the Grand River.

The surveys made the distance from Jujuy to La Quiaca, the frontier custom-house of Argentina, 178 miles. From La Quiaca to Tupiza, in Bolivia, is 50 miles.

After the quebrada widens, like the opening of a funnel, the ascent is a gradual one till the pass at the summit is reached. This is 12,215 feet above the sea. It is sometimes called the "Abra" or "Gateway of Three Crosses." After that there is a gradual descent through the wide plains lying between the roller top mountains. I found this region very sterile, though the vegetation was enough to nurture great flocks of sheep. From the valley of Quiaca, 11,265 feet above sea level, there is a rise in the Bolivian territory and then a descent through the valley of the San Juan River to Tupiza. Tupiza is 9,670 feet above sea level. This town, which now has about 5,000 inhabitants, in time will become the commercial metropolis of southern Bolivia, for the railroads will center there and branch into different directions. It will be a station for the Atlantic and also for the Pacific.

From Tupiza to Uyuni the trail, which is also the only available route for a railway, leads through canyons and across the two spurs of the Royal Cordillera, known as San Vicente and South Chichas. This section is the most difficult one in Bolivia. However, it is not impracticable and the immense mining resources of the region traversed are in themselves a sufficient justification for railway building. There are many gorges and gashes, along some of which I found that there was not too much room for a single mule, but these can be overcome by means of tunnels. The pass which is the gateway for the railroad is about 14,000 feet above sea level. It is the natural opening to the great plain on which the town of Uyuni lies.

No detailed survey has yet been made of the route from Tupiza to Uyuni, though observations have been taken by various commissions. The distance is between 125 and 130 miles.

For the intercontinental location in Bolivia this Uyuni-Tupiza link is about the only important engineering problem. Once Uyuni is reached all else is simple. The present railroad, which begins at Antofagasta on the Pacific coast, after reaching Uyuni continues across the great pampa to the mining center of Oruro. The section to be closed is that from Oruro to Viacha on the railway that connects Guaqui on Lake Titicaca with La Paz. The distance is 128 miles. The region traversed is the altiplancie or table-land, plain and valley rarely below 12,000 feet, with some broken country, but with little topography requiring tunnels or even many bridges or viaducts.

An inquiry may be made why the intercontinental railway should follow the coast line instead of striking into the more distant interior. In answer I would say that while the general line as far as Lake Titicaca may be said to parallel the coast, in reality the location is pretty well in the interior and it traverses the regions most open to development and traffic. That is part of the question of commercial rather than of physical geography, but on this general subject of a longitudinal railway the example of Chile may be cited. Of all countries it might be said that she, with her 2,700 miles of coast and a maximum width of 102 miles, needs only transverse lines running from the Cordillera to the seaports. But Chile has shown the utility of a longitudinal line, and the one which traverses its great central valley to Santiago unquestionably in time will be prolonged to the nitrate fields of the north.

Maritime transportation never yet developed a country 50 miles inland. What is necessary is the main trunk, with branches. If you will glance at the map of the western coast of South America and note the present railway lines which start at the seacoast and run nowhere, the advantage of a trunk to which they can be extended and through which a general system of railway intercommunication can be established will be apparent. These little railroad spurs

follow the water courses and find their way to the edge of a vast territory, but stop there.

This question of branches is a broad one, for it includes reaching the Atlantic from the eastern slope of the Andes and also the Pacific from the Amazonian region. The intercontinental survey merely made tentative suggestions on this point, but now something far more tangible can be reported. I may refer again to political geography in order to indicate that Bolivia is midcontinent country. It has outlets to the Pacific, but reasons of national policy make desirable easy access also to the Atlantic. When the Argentine railways are prolonged to Tupiza, southern and southeastern Bolivia will have that alternative route by the river Plata to the world's markets. Moreover, under the present Bolivian railway policy, through rail and water navigation is to be secured to the Amazon and thence to the open sea. The Government is planning an electric system from La Paz to the tropical territory northeast of La Paz known as the "Yungas." This scheme has many topographic difficulties, for the great barrancas have to be surmounted and there is no easy descent to the valleys. But it is not beyond engineering skill, and the headwaters of the Beni River will be reached. Thence there is navigation to Villa Bella, the Bolivian customs outpost at the confluence of the Madre de Dios and Mamore rivers. From this point the Brazilian Government, under its treaty agreement, is to build a railway between the Madeira and the Mamore around the falls of St. Anthony, a distance of about 300 miles.

This project is an old one. Former attempts under private enterprise were unsuccessful, partly because of the lack of financial resources and partly through a failure to understand the climatic necessities. But as a Government measure there is no reason to doubt that it can be carried through. Then the intercontinental railway system will be interconnected by means of water navigation with the Atlantic coast at the mouth of the Amazon as well as at the mouth of the River Plata.

In another sense the intercontinental project affords greater possibilities since it has encouraged Peru to undertake to connect the headwaters of the Amazon with the Pacific coast. The explorations of Tucker, Werthemann, Barandiaran, Wolff, Father Sala, Perez, and others established river navigation from Iquitos to Port Bermudez by means of the Ucayali and its branches, a distance of 1,000 miles. Less, perhaps, is known of the central highway of Peru, which opened up communication from the Oroya Railroad to Port Bermudez. Though this central highway for much of the distance is only a trail, it has shown the feasibility of a railway route. The Peruvian Government has surveyors in the field making the detailed studies for this

project, which will be the first transcontinental line from the Pacific to the Amazon. The distance is about 220 miles. The pass is 14,000 feet. This is less than that surmounted by Henry Meiggs on the Southern Railroad from Arequipa to Puno, and considerably less than the Galera tunnel on the Oroya Railroad, which was also built by Meiggs and which is 15,665 feet above sea level.

I might generalize the whole engineering question of the intercontinental route from Mexico to Argentina, and say that there are no problems so formidable as those which were solved by Mr. Meiggs in the railroads he built in Peru thirty years ago. Geographically and in the engineering sense there is not much difference between one series of mountain masses and another series of mountain masses. The real question is the economic and commercial one; that is, how far government aid can encourage and supplement private enterprise to surmount these difficulties. This would make it necessary to enter into the subject of commercial and industrial geography, and the time allotted me forbids more than a sentence or two on that point. I can only call your attention to the measures already adopted by the Bolivian, the Peruvian, and other governments to insure a continuous and coordinated national railway policy. With regard to traffic it should be apparent that local traffic and development are the main incentives to this intercontinental railway construction. For that reason local geography is to be studied.

FUTURE EXPLORATION IN AUSTRALIA

By DAVID LINDSAY, Adelaide, Australia

In 1895 I had the honor of reading a paper before the Sixth International Geographical Congress in London on the subject you have assigned me for to-day. I approach the task fully aware of the honor you have done me and with much diffidence.

Since 1895 much of the then unexplored country in the Australian Commonwealth has been examined by explorers Wells and Carnegie, a West Australian government party, and prospectors; consequently the scope of this paper is very limited.

Geographically speaking, but little of Australia remains unknown. If we turn to a late map of the great island continent we shall find certain blank spaces with dotted lines indicating the routes followed by explorers who have bravely struggled against the forces of nature. As the country in question consists for the most part of rolling, sandy deserts, covered with *Triodia irritans*, the spinifex of explorers, with an occasional outcrop of sandstone, it is evident that not much to interest geographers has yet to be discovered. But to the prospector and miner, to the geologist, botanist, entomologist, and ethnologist a great deal of Australia is still unexplored. Vast tracts and small isolated areas of metalliferous rocks, which promise well for minerals, have never been seen by anyone versed in geology, while still larger tracts conceal very interesting problems awaiting the advent of the botanist and naturalist. The ethnologist also would find a great and intensely interesting field in the study of the origin, habits, customs, language, and folk lore of the aboriginal inhabitants. Only in the central region of the continent has this subject received the attention it deserves from men capable of understanding it and extracting the truth from the natives. Reference to the accurate and highly interesting book written by Mr. Gillen and Professor Spenser on the aborigines of Central Australia will show that it is necessary for the ethnologist to live among the natives before he can obtain the knowledge and information required to enable him to arrive at a

conclusion as to the origin of a people who are perhaps the most primitive race existing anywhere in this world. The origin of some of their customs is shrouded in mystery, and yet it indicates a remote connection with a more intelligent people at some period of their history. Some of the tribes practice circumcision and other strange rites of mutilation, and it has been stated that distinct masonic signs were made by a certain inland tribe on its first seeing white men.

An eminent German scientist has recently given publicity to his theory that Australia was the original home of the human race, because in it were no wild animals to interfere with the growth and development of a creature born helpless and unable to move about or defend itself. The climate, too, would permit of the naked infant living. This theory, based though it is, I am afraid, on insufficient grounds, still shows how interesting the search for information as to the origin of these people must be.

Australia has been well described as "the land of the dawning; birds without wings; bees without stings; dogs that do not bark: trees without shade; rivers without water." This latter is a marked feature of central Australia, where the traveler finds a water course which he may follow for hundreds of miles without seeing any water; yet periodically floods pass down these channels to eventually sink beneath the sands, helping to supply the great subterranean reservoir which is being tapped by the diamond drill to provide water for the immense herds of cattle and sheep which roam over the great inland plateau of eastern-central Australia.

Exploration in the future, to have any value or interest, must be carried out by thoroughly equipped scientific expeditions, with plenty of time at their disposal to make close and careful examination to find out whether gold or other minerals exist, as an inducement to population to go far from the coast and from civilization. These expeditions must not, like some of the explorers of old, as well as some of the recent prospecting expeditions, simply look for grass and water, or rush with all possible speed across the inhospitable deserts, with the one object in mind of getting away forever from the awful solitudes of a country deserted by all forms of life, and apparently left by the Creator in an unfinished condition.

I hold that, unless gold be found, vast areas aggregating many thousands of square miles must forever remain as we now find them, enshrouded in the mysteries which surround the fate of brave explorers and bushmen, who have left their bones to whiten in the blistering sun.

Two prospecting parties have just set out from Adelaide for the interior in the search for gold fields. The examination of these unknown regions is no longer a difficult or dangerous undertaking, as

waters, have been located, and, given a good season, excursions can safely be made from these oases, as depots, into the desert regions on either hand.

The great feat of crossing the continent from south to north, accomplished by John McDonall Stuart, established a base line from which explorations could be made. Stuart was fortunate in having good rainy years for his journeys. Since then many explorers have experienced droughts and found it impossible to cross the desert tracts lying to the west of his route. To illustrate the waterless character of the great regions in central-west Australia, I may mention that in 1891 I led a party, consisting of 14 men and 42 camels, across the Great Victoria desert, a distance of 535 miles, the trip occupying thirty-five days, without finding enough water to give the camels a drink. In fact they had only 7½ gallons each during the whole of that time, a feat of endurance which has never been surpassed in any country.

Briefly to summarize: Since there are no mountains or rivers and no large tracts of habitable land to be found in the unexplored portions of the continent, the future exploration must resolve itself into a geological examination of not only the unmapped regions, but also of the great areas which have not yet had the attention of the geologist or miner.

THE PLACE OF THE TOPOGRAPHIC MODEL IN GEOGRAPHY

By GEORGE CARROLL CURTIS, Boston, Mass.

[Abstract.]

Many of the forms of the earth's surface are of such large proportions that it is practically impossible for man to see them as entireties. Airships will perhaps eventually permit better access to bird's-eye viewpoints over broad areas, but we shall still be restricted to a single point at a time and be hampered by limits of vision and atmospheric interruptions. Maps supply our needs in respect to the horizontal boundaries of geographic form, and raised or relief maps suggest relations of its elevations, while photographs furnish monotint views of details, but there seems to be no other means to reproduce the exact features of the land except by topographic models.

The sciences of zoology and botany rely on the microscope for much of their work, but many of the forms which geography presents must be reduced in order to be studied in a convenient and comprehensive manner. The truthful topographic model on which the forms are reproduced without errors supplies this need. It seems fair to assume that had geography reached the advanced stages of development which zoology and botany to-day occupy, the topographic model would have played its essential part in the progress.

While arbitrary reliefs have long been employed, the work of truthfully modeling the earth is of necessity a modern one, for its development has awaited the invention of accurate maps, dry-plate photography, and the knowledge and stimulus of the modern understanding of land forms.

Now and then there appears among anatomists one whose special training and abilities qualify him as an expert judge of figure sculpture; so there have been among geologists men whose experience and specialization have qualified them as experts in reproducing geographic forms. The work these men have given to the world indicates the advantage to be derived from leaving to experts matters pertaining to the principles and methods of such exacting work.

A comparison of geographic models with works in other arts and their underlying sciences will induce a broader and more generous view of the subject among geographers and geologists, and will tend to enrich the science of geography and broaden its field of influence.

THE CHRONOMETER AND TIME SERVICE OF THE UNITED STATES NAVAL OBSERVATORY AND THE PRESENT STATUS OF STANDARD TIME

By Lieut. Commander EDWARD EVERETT HAYDEN, U. S. Navy

CHRONOMETER AND TIME SERVICE.

This department of the Observatory has charge of all naval chronometers and of the telegraphic time signals that drop time balls in the principal seaports for the benefit of navigation and give standard time to the entire country except the Pacific coast, which gets it from the Observatory at the Mare Island navy-yard, Cal.

There are in all about 700 chronometers in the naval service, including 450 mean-time standards, 20 sidereal standards, 180 "hack" chronometers, and 50 torpedo-boat watches. These are of course distributed widely on board of naval vessels, although there are usually as many as 50 at this Observatory in readiness for issue, and a number at such substations as the Mare Island navy-yard, Cal., and Cavite navy-yard, P. I.

New chronometers submitted for trial and purchase undergo a long and rigorous trial, beginning in January of each year and ending in June, consisting of ten weeks in the temperature room at temperatures from 50° to 90° F., and ten weeks in the chronometer room at normal temperatures. During this trial their errors and rates are noted daily by comparisons on a chronograph with standard clocks whose errors and rates are known from frequent star sights with a transit instrument, and their rates for seven-day periods are used to obtain a trial number for each instrument by means of an empirical formula, the result of long experience and study by various naval officers, that gives due weight to each of the four following qualities:

(1) Temperature of compensation.
(2) Curvature of the rate curve.
(3) Running in the temperature room.
(4) Running in the chronometer room.

Those who are specially interested in the subject can find more exact details of this trial in the annual report of the superintendent of this Observatory for the fiscal year ending June 30, 1902, which need not be quoted here.

As the result of such trial, chronometers are either rejected or purchased at prices varying according to the trial number obtained, the best of them gaining a premium by their good qualities and the results of each trial being published in the following annual report of the superintendent. In the last trial there were entered 133 chronometers, of an aggregate value of $31,000.

When chronometers are required for issue they are transported with great care by a naval officer, detailed by the Department for the purpose, and an exact statement of their errors and rates at different temperatures is prepared at the Observatory and forwarded with them to the navigator of the vessel, who then takes up and continues the records by means of his own observations, assisted by such comparisons as can be obtained by means of time balls established in the various ports that he may visit.

Each large naval vessel has an allowance of three standard chronometers and one "hack," a less valuable instrument used to carry on deck or ashore for purposes of comparison. New chronometers, or others freshly cleaned, are expected to run continuously for four years before they need to be cleaned again.

The necessity for absolutely correct time in connection with naval chronometers and time balls led very naturally to the extension of the time service throughout the country, and a five-minute series of telegraphic time signals, ending at noon of the seventy-fifth meridian west from Greenwich, is now sent out daily to every part of the country, and even to Habana and Panama, by the cordial voluntary cooperation of telegraph, telephone, and cable companies. In fact, for this five-minute interval practically all business over the wires is suspended for the transmission of these signals, so that the transmitting clock may be said to be heard in every telegraph office in the country.

The adoption of standard time by the American Railway Association, with the support of the Naval Observatory, in 1883, simplified enormously every kind of business in which accurate time is a factor, and at present standard time, based on the meridian of Greenwich, is in use in every portion of the United States and its possessions, as shown by the tabular statement below. The advantages of a system where the minutes and seconds are the same everywhere, only the hours changing, are too great to require explanation, and the tendency now is for all nations to adopt a system based on the same prime meridian, that of Greenwich, to facilitate the conversion of time in all international relations.

The following statement regarding a special time signal sent out by this Observatory last New Year's Eve illustrates very well the possibilities of the system when the various telegraph, telephone, and cable companies take it up with interest and energy.

TELEGRAPHIC TIME SIGNALS, NEW YEAR'S EVE, DECEMBER 31, 1903, AND JANUARY 1, 1904

The following abstracts of reports received by the Superintendent of the United States Naval Observatory, together with wide and favorable comment in the daily press, illustrate the extent to which the signals marking the exact instant of the beginning of the new year were distributed by means of the cordial and voluntary cooperation of the telegraph, cable, and telephone companies. This was only the second time that the plan has been tried, but it has met with such success that it will probably become a regular feature of the Observatory routine work. The system of signals is the same as that used daily at noon, the first series beginning at five minutes before midnight, seventy-fifth meridian time, and ending at midnight, followed by other series ending at 1, 2, and 3 a. m. for Central, Mountain, and Pacific Coast midnight, respectively. The rapidity with which they are transmitted is shown by the fact that they were accurately timed at the Lick Observatory, California, with a delay of only $0^s.05$; at the National Observatory of Mexico, $0^s.11$; at the Royal Observatory, at Greenwich, England, $1^s.33$; at Sydney Observatory, Australia, $3^s.50$, and at Wellington Observatory, New Zealand, 4^s. In addition to its merely sentimental interest this plan is regarded as important in its bearing upon the general recognition and appreciation of accurate standard time and of the adoption everywhere of a common and harmonious system based upon the meridian of Greenwich, which is already accepted by seventeen of the thirty-three nations that use standard time, each of the other sixteen using a system differing from all the rest and based on its own prime meridian. As a result of the universal adoption of such common standard the conversion of the time of one nation into that of another will not involve dealing with minutes and seconds at all, these being the same everywhere and only the hours or half hours differing, thus greatly simplifying all international business in which any question of time is an element.

The abstracts of reports received regarding the New Year's eve telegraphic time signal are as follows:

[Western Union Telegraph Company, R. C. Clowry, president.]

Have completed arrangements for dissemination New Year's time signals over lines of this company to every point of any importance in the United States and over our Atlantic and Cuba cables. Will also deliver the signals at Galveston to Central and South American Telegraph Company for dissemination in Central and South America. Will use one of the two Anglo-American cables to Penzance for transmission of signals to England, where they will be taken up by Government telegraph lines and sent to the Royal Observatory at Greenwich. The signal was transmitted over at least 186,173 miles of our land lines, as well as over the length of our Atlantic cable route.

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NOTE.—This company delivered the signals to the Great Northwestern Telegraph Company, and also to its connecting company in Canada, and is entitled to credit for the practically instantaneous transmission to the Greenwich, Lick, and Mare Island observatories. In acknowledging this service the Superintendent of the Naval Observatory stated that it was striking and valuable evidence of the accuracy with which the daily noon signals are transmitted by the company to the various time-ball stations in the United States.

[Postal Telegraph Company and Commercial Pacific Cable Company, Clarence H. Mackay, president; George G. Ward, vice-president and general manager.]

The four series of New Year's eve time signals were duly passed on by the Postal Telegraph Company to the Commercial Pacific Cable Company, and were transmitted to Honolulu, Midway, Guam, and Manila. Officers of the United States Coast and Geodetic Survey at Guam caught the last signal on a chronometer, which was taken on board and compared with that of the U. S. S. *Supply* and showed a difference of eighteen seconds. Arrangements had been made at Manila to pass the signals on to the Signal Corps, to be transmitted along the military telegraph lines, but it is regretted that faulty local wire service prevented the arrangement from being carried out. The following reply was received to message requesting the cooperation of the Eastern and Eastern Extension Telegraph Company: "With every desire to fall in with views there are so many factors to take into account to make the experiment a success that the companies would prefer not to disorganize traffic for what might turn out to be a failure. The signals would have to be repeated by hand sixteen times, as follows: New York, Azores, Lisbon, Gibraltar, Alexandria (through land lines to) Suez, Aden, Bombay (over the Government land line to) Madras, Singapore, Hongkong, Manila, Guam, Midway, Honolulu, San Francisco."

NOTE.—The Postal Telegraph Company delivered the signals to the telegraph department of the Canadian Pacific Railway Company, its connecting company in Canada, by whom they were transmitted east to Sidney, Nova Scotia, west to Vancouver, British Columbia, north to Dawson and Eagle City, Alaska, and by Pacific cable to Fiji, Australia, and New Zealand.

[Central and South American Telegraph Company and Mexican Telegraph Company, James A. Scrymser, president; James R. Beard, secretary.]

I take pleasure in informing you that the transmission of the midnight signal (via Galveston) has been duly arranged with our managers at Panama, Lima, Iquique, Valparaiso, Santiago, Buenos Ayres, and City of Mexico. The time of its receipt will be duly reported. * * * I asked Buenos Ayres to signal back letters "BS" immediately on receipt of midnight signal and stations to keep line clear until these letters had passed. Forty-seven and one-half seconds after signal left Galveston the letters "BS" were signaled back from Buenos Ayres, which includes time of the return journey. I calculate times received at our stations as follows, in seconds: Galveston 1, Coatzacoalcos 4, Santa Cruz 7, San Juan 10, Panama 13, Santa Elena 13, Barranco 16, Iquique 19, Valparaiso 22, Buenos Ayres 25, Veracruz 2½, City of Mexico 4½.

[American Telephone and Telegraph Company, Frederick P. Fish, president; Edward J. Hall, vice-president.]

The New Year's eve signals were transmitted over the lines of this company to our office at New York, Philadelphia, Columbus, Chicago, St. Louis, and Atlanta, and there distributed to such of the connecting local telephone companies as desired them. Two methods were employed in giving them to subscribers listening at their own telephones. In one case a transmitter was placed close to the sounder in the main circuit and a secondary telephone circuit multiplied throughout the sections of the local exchange switch board. The loop of any subscriber wishing the signals was connected with this multiplied circuit by plugging in on it in the usual way. In the other method a tone circuit which was normally open was multiplied throughout the sections of switch board, and the impulses sent from your observatory were used to close the tone circuit through a relay, so that the subscriber who plugged in on it could hear the buzz each time that your relay operated.

[Department of State, through Hon. A. A. Adee, Assistant Secretary.]

We are in receipt this morning of a telegram from our embassy at Mexico City stating that the directors of the Mexican telegraphs and of the national observatory will comply with your wish to have the receipt of the telegraphic time signals which you will send out on New Year's eve timed accurately in the City of Mexico.

[Signal Corps, U. S. Army, A. W. Greely, brigadier-general, Chief Signal Officer.]

In view of the fact that the Chief Signal Officer of the Army initiated and secured the approval of the application of standard time to Porto Rico, Cuba, and the Philippine Islands, he naturally takes great interest in matters of this kind. Instructions have been sent to the signal officer of every department to extend any and all facilities in this connection. It is hoped another year that the Signal Corps of the Army will be able to furnish a definite cable route for the transmission of such signals from Seattle to Sitka and then to St. Michael. I have sent the following cablegrams: "Signals, Manila: Cooperate with Naval Observatory distributing time January 1; naval officials should be consulted." "Erickson, Skagway, Alaska: Any time signals received January 1 should be sent Sitka, Juneau, noting time * * *." The operator in charge at Sitka, Alaska, reports that all four series of signals were received. To have reached Sitka they must have traversed lines in the United States, British Columbia to Tagish, thence to Skagway, and by Signal Corps cable via Juneau to Sitka.

[Lick Observatory, California, W. W. Campbell, director.]

The time signals were received at this observatory by telephone from the sounder in the Western Union office at San Jose at 10, 11, and 12 o'clock, and a comparison made with the beats of a sounder electrically connected with our own standard clock. It so happened that the standard clock at this place was exactly correct at midnight, so that in making a comparison no correction was needed. At 10 o'clock and 11 o'clock the comparisons were made by listening to both sounders—one through the telephone receiver, the other in the telephone, both beside the observer. The sounders beat very nearly together, but it was thought that the Washington clock beat about $0^s.05$ after our own clock. At 12 the two clocks were compared upon a chronograph—the observer in the telephone booth hearing only the beats of the Washington clock and recording

them by breaking an electric circuit connected with the chronograph. The chronograph sheet was read later and for a series of twenty consecutive records showed the Washington clock to beat $+0^s.047$ later than our own.

[Observatory of Mare Island Navy-Yard, Cal., F. H. Holmes, commander, U. S. Navy, in charge.]

All the apparatus was in excellent condition and all ticks came in very clearly, and records made on two chronographs have been preserved. The time received was expected to be a little later than our calculations should show, but, on the contrary, they were received just one-tenth of a second earlier by the mean time and sidereal clocks, which agreed exactly. The time December 31.5 was carried forward from an excellent sight of the 29th.

[National observatory of Mexico, Tacubaya, Felipe Valle, director.]

The signals were registered here on a chronograph. The first series received, allowing for the accepted longitude of the observatory, averaged $0^s.271$ for the delay in transmission. The fourth series, $0^s.110$, giving an average for the two of nineteen-hundredths of a second. It will be a great pleasure for me to note and report once more, at the end of this year, the wished-for sets of signals referred to in your letter.

[Government Telegraph Service of Canada, D. H. Keeley, general superintendent.]

I have sent a message as follows to the acting superintendent at Vancouver. British Columbia: "Understand Postal Telegraph Company is cooperating with Observatory for transmission of time signals fixing the New Year; you might please ascertain what action needful to extend the signaling as far as possible on our Yukon line." I may state that the circuit is operating when practicable all the way through from Vancouver to Dawson, with automatic repeaters at Hazelton and Atlin. The distances are as follows: Vancouver to Ashcroft, 214; to Hazelton, 588; to Atlin, 550; to Dawson, 690; total, 2,042. If the lines are working, it might be possible to get the signals through to the next distant points of your Alaska system, with which ours connects at the boundary.

[Canadian Pacific Railway Company, Sir Thomas G. Shaughnessy, president, through James Kent, manager of telegraphs.]

Shall be pleased to put the Postal wire through to Vancouver and Dawson, via Ashcroft, and to the Pacific cable terminus at Bamfield, British Columbia. Also to give you a connection with the Halifax and Bermudas Cable Company, which will probably be able to give a circuit to Jamaica. * * * Time signals were automatically transmitted to all the principal points in Canada as far east as Sydney, Nova Scotia, and west to the Pacific cable landing in British Columbia. From Vancouver they were automatically retransmitted as far as Eagle City, Alaska, over Central Pacific Railway line to Ashcroft, Dominion government line to Dawson, and American Government line to Eagle City, which they reached in excellent condition. At Bamfield they were automatically retransmitted to the Pacific cables. Sydney observatory, Australia, reports that second series was very satisfactory. Wellington observatory, New Zealand, reports that the final signals took four seconds in transmission. Should you contemplate a further experiment of this kind, I have no doubt that we could transmit the signals to Australia and New Zealand in still better shape.

[Great Northwestern Telegraph Company, Canada, J. McMichael, general manager.]

The New Year's time signal was distributed over our lines last night to the extent of 5,035 miles of wire.

[Royal Observatory, Greenwich, England, through Evan MacGregor, permanent secretary of the Admiralty.]

The signal sent out from the Washington Observatory was received on the morning of January 1 at $5^h\ 0^m\ 1^s.1$ by the Greenwich mean solar clock. The clock was 0.23 second slow at the time. The signal was therefore received at $5^h\ 0^m\ 1^s.33$, Greenwich civil time (a delay of only 1.33 seconds in transmission over land lines and cable from the Naval Observatory in Washington to the Royal Observatory at Greenwich).

[Adelaide Observatory, Australia, Sir Charles Todd, Government astronomer for South Australia.]

On the morning of January 1 I received a telegram from the Brisbane office that by arrangement with the Pacific cable board the Washington Observatory would transmit a series of time signals that afternoon through the Pacific cable to Southport, in Queensland (the landing place), thence to be simultaneously repeated over the Australian land lines to the several observatories. I made all necessary arrangements for receiving the signals and comparing them with our transit clock, sending one assistant to the Adelaide telegraph office with a chronometer and personally noting the signals at the observatory.

NOTE.—The mean of the second series gave twenty-two seconds for the elapsed time.

[Sydney Observatory, Australia, H. A. Lenehan, acting Government astronomer.]

The telegraph department here was shorthanded, being a holiday, and as we had earth on the end of our line at the observatory we could not, on the short notice, have the loop line put up. Under the circumstances, if we had the signals sent to us the other states of the commonwealth would have been shut out. This necessitated my attending with a chronometer at the telegraph bureau. The contacts were not regular in reaching us and they had the sound of being transmitted by hand, the variation in the fractions of seconds being very marked, but under the circumstances I consider that the result was good, the second set being the best. * * * The final signal of the third set was received at $6^h\ 0^m\ 3^s.5$ p. m., Sydney standard time, corresponding to 3 a. m. at Washington.

NOTE.—This indicates the very short interval of three and one-half seconds from Washington to Sydney, differing from Adelaide, but agreeing with one report from Wellington, as stated below.

[Post and telegraph department, New Zealand, W. Gray, secretary; observations by Thomas King at Wellington Observatory.]

According to the programme, Washington was to send this (second) set at eastern mean time, 1 a. m., which corresponds with New Zealand mean time, 5.30 p. m. Assuming the signals to have been sent as intended, the time occupied in transmission would thus appear to be twenty seconds. The last signal of the fourth set was received at $7^h\ 30^m\ 4^s$, which ought, in order to be consistent with the earlier portions of the set, to have arrived when the Wellington

clock was at thirty-three to thirty-four seconds. If Fiji's satement was correct, that the solitary click at $7^h\ 30^m\ 4^s$ was the end of the five-minute series, it would mean that this signal had come through in about four seconds. As was to have been expected, in view of the conditions under which the signals had to be transmitted, they did not by any means arrive at true one-second intervals. The clock on which the times were taken at Wellington was correct to within a second.

The above reports show that the New Year's eve signals were transmitted over about 300,000 miles of wire within a few seconds after they had left the Observatory. They reached from England on the east to the Philippines, Australia, and New Zealand on the west, and from Sitka, Alaska, to Buenos Ayres, Argentina, thus covering about three-quarters of the civilized world. As the plan becomes better known they will doubtless receive still wider circulation, and with the universal use of standard time based on the meridian of Greenwich and the assistance of wireless telegraphy the time may come when there will be a daily noon signal that will reach every nation and ocean of the globe.

In connection with this necessarily brief account of the transmission of these time signals, a graphic illustration of which was given to this present Congress by means of the series of midnight signals sent out at the close of the reception at the Naval Observatory on September 8, I wish to make a suggestion that I think may still further increase their usefulness and at the same time lead to important results in a very different field.

Our Government has occasion from time to time to make important public announcements that require, for the interests of all concerned (and very great public and private interests are often involved), immediate and very widespread circulation in accurate and authoritative form. Such news, for instance, as the latest Government crop reports, the publication of which affects the markets of the world, demands simultaneous publication everywhere, or great dissatisfaction will result. What better way could there be to insure instantaneous and world-wide circulation for such important official news than to put it on the wires at the Naval Observatory, while the telegraphs, telephones, and cables of an entire continent are thrilling in unison with our standard clock, and while for a few brief minutes the Government, with the cordial support of all the companies, is exercising the right of eminent domain over all their lines? We think that we can safely say "Sign, seal, and deliver your message to us at noon and in a few seconds we will manifold it over the wires and cables of the United States or of the world with an exact record on our chronograph of every dot and dash that went out over the wires."

PRESENT STATUS OF STANDARD TIME

The following abstracts of official reports received by the superintendent of the United States Naval Observatory, through the courtesy of the Department of State and of the Office of Naval Intelligence, Navy Department, give a fairly complete idea of the kinds of time in actual use in various countries and of the changes that are necessary in order to secure the universal adoption of a common standard.

The object of standard time is to avoid the use of local mean time by using the time of a single standard meridian that is near enough to serve the purpose, and preferably a standard in harmony with other systems all over the world. With such harmonious standards the time of any one country is either the same everywhere or else, if its territory be very large, it is the same within a wide region and differs by exactly an hour in adjacent standard-time belts. For example, in the United States, where the seventy-fifth, ninetieth, one hundred and fifth, and one hundred and twentieth meridians west from Greenwich are the standard time meridians for Eastern, Central, Mountain, and Pacific Coast time, respectively, there is now no such confusion as there used to be when each city and town had its own local mean time. At present the noon signal that is telegraphed all over the country from the Naval Observatory serves to set clocks and watches everywhere, only the hour differing and the minute and second being exactly the same. The advantage of this system is especially great to railroad, telegraph, telephone, and cable companies, but it is now recognized as essential in all business relations, not only for internal commerce, but in international affairs, and it has become very desirable to extend the same system throughout the entire civilized world.

The following data, collected in order to show the actual present status of the use of standard time, will serve for reference in converting the time of one country into that of another and to encourage the general adoption of the standard that is already in such common use:

Country.	System of time in actual use.	Difference from Washington standard.	Earlier or later.
		h. m. s.	
Alaska	See United States.		
Algeria	See France.		
Anam	Do.		
Argentina	The official time in use throughout the Argentine Republic is referred to the meridian of Cordoba, 4h 16m 48s.2 west from Greenwich. At 11 a. m. a daily signal is telegraphed from the Cordoba Observatory. The greatest deviation of local mean time from the official time would not exceed 26 minutes. La Plata is 25m 45s east from Cordoba, and Mendoza, the most western town of importance, is 18m 32s west from Cordoba.	0 43 11.8	Later.

Country.	System of time in actual use.	Difference from Washington standard.	Earlier or later.
		h. m. s.	
Australia	See England.		
Austria-Hungary	Standard time does not exist in Austria except for the service of the railroads. Central European time, 15° east from Greenwich, is required to be used by all the railways. This is not a matter of law, but is in force by order of the proper authorities.	6 0 0	Later.
Bahamas	See England.		
Bermudas	Do.		
Bismarck Archipelago.	See Germany.		
Borneo	See England.		
Cambodia	See France.		
Canada	See England.		
Carolines	See Germany.		
Chatham Island	See England.		
Belgium	Official time in Belgium is calculated from 0 to 24 hours, zero corresponding to mean midnight at Greenwich. The Royal Observatory at Brussels communicates twice daily the precise hour to the central telegraphic administration and Government offices, also to important corporations. The telegraphic administration transmits it to the other towns in Belgium.	5 0 0	Do.
China	An observatory is maintained by the Jesuit mission at Zikawei, near Shanghai, and a large ball suspended from a mast on the French bund in Shanghai is dropped electrically precisely at noon each day. This furnishes the local time at the port of Shanghai, which is adopted by the railway and telegraph companies represented there, as well as by the coastwise shipping. From Shanghai the time is telegraphed to other ports. The cable companies represented in Peking receive this time from Chefoo; the Imperial Chinese telegraphs from the office of that company in Tientsin. The imperial railways of north China use the same time, taking it from the British gun at Tientsin and passing it on to the stations of the railway twice each day at 8 a. m. and 8 p. m. No information yet from the Peking-Hankow Railway.	13 4 43.3	Do.
Cochin-China	See France.		
Colombia	At Bogota the time used is that of the meridian of Bogota. This time is taken every day at noon in the observatory, but there is no method employed in correcting this time daily by signal from a central observatory. Some few people, such as jewelers, go to the observatory daily; but the great mass of business men, railroad officials, etc., let their time run sometimes for weeks without correcting it, until the inconveniences caused thereby compel them to make the necessary corrections. As far as communicating the time as corrected in Bogota to other parts of the country is concerned this is rendered impossible by the very poor telegraph service, it frequently taking four and five days to send messages a distance of from 50 to 100 miles.	0 3 5.8	Do.
Costa Rica	The Government has established an observatory at the capital, San Jose, in latitude 9° 56′ north, longitude 84° 04′ 14″ west from Greenwich; altitude, 4,567 feet, or 1,160 meters, above sea level. The Greenwich meridian is used exclusively to regulate observatory time, which is corrected by observation and reduced to mean time. This time is issued to public offices, railway and telegraph offices, churches, and to all residents whose occupations necessitate correct time. There is no method employed to correct time by signal from the observatory, the corrected time being taken by applicants from the standard chronometer at the observatory.	0 36 13.1	Earlier.
Cuba	The official time of the Republic is civil mean time of the meridian of Habana, and is used by the railroads and telegraphic lines of the Government. The central meteorological station gives the time daily to the port and city of Havana as well as to all the telegraph offices of the Republic.	0 28 50.4	Do.
Danish West Indies	See Denmark.		

Country.	System of time in actual use.	Difference from Washington standard.	Earlier or later.
		h. m. s.	
Denmark	Standard time is fixed at one hour earlier than that of Greenwich, corresponding to mean solar time of the fifteenth degree of longitude east from Greenwich. In Iceland, the Faroe Islands, and the Danish West Indies local mean time is used.	6 0 0	Later.
	Local mean time for the Danish West Indies gives for—		
	Curaçao	0 24 18.1	Do.
	St. Thomas	0 40 17	Do.
Ecuador	The legal and common time is that of the meridian of Quito. It is corrected daily from the National Observatory of Quito.	0 15 1.0	Earlier.
England	The meridian of Greenwich is the standard time meridian for England, Scotland, the Orkneys, Shetland, the Isle of Man, and Gibraltar.	5 0 0	Later.
	That of Dublin (25^m 21.1^s slow of Greenwich) for Ireland.	4 34 38.9	Do.
	Longitude 15° east for Malta	6 0 0	Do.
	Longitude 30° east for Cape Colony, Transvaal, Orange River Colony, Rhodesia, Natal, and Egypt.	7 0 0	Do.
	The meridian of Fort Fullerton, Singapore (6^h 55^m 25^s fast of Greenwich) for Straits Settlements.	11 55 25	Do.
	Longitude 120° east for West Australia	13 0 0	Do.
	Longitude 142½° east for South Australia, including northern territory.	14 30 0	Do.
	Longitude 150° east for New South Wales, Queensland, Tasmania, and Victoria.	15 0 0	Do.
	Longitude 172½° east for New Zealand and Chatham Island.	16 30 0	Do.
	Longitude 120° west for Alberta, Assiniboia, and Athabasca.	3 0 0	Earlier.
	Longitude 90° west for Keewatin and Manitoba	1 0 0	Do.
	Longitude 75° west for Montreal, New Brunswick, Ontario, and Quebec.	0 0 0	
	Longitude 60° west for Nova Scotia and Prince Edward Island.	1 0 0	Later.
	Assuming local mean time for other British colonies gives the following results:		
	Antigua	0 40 0	Do.
	Arabia (Aden)	7 59 54	Do.
	Bahamas (Nassau)	0 9 29.5	Earlier.
	Barbados (Bridgetown)	1 1 30.8	Later.
	Bermudas (Hamilton)	0 40 41.7	Do.
	Borneo (Labuan)	12 41 1	Do.
	Hongkong	12 38 41.7	Do.
	Falkland Islands (Port Stanley)	1 8 34	Do.
	Fiji Islands (Suva)	16 55 44	Do.
	Guiana (Demerara)	1 7 20.5	Do.
	Honduras (Belize)	0 52 47	Earlier.
	India:		
	Madras	10 20 59.1	Later.
	Calcutta	10 53 20.8	Do.
	Bombay	9 51 15.7	Do.
	Jamaica (Kingston)	0 7 10.4	Earlier.
	Newfoundland (St. Johns)	1 29 10.5	Later.
	Trinidad (Port of Spain)	0 53 57.5	Do.
	NOTE. Local mean time of the Madras Observatory is practically used as standard time for India and Ceylon, being telegraphed daily all over the country, but for strictly local use it is generally converted into local mean time.		
	NOTE.—Local mean time of St. Johns is practically used as standard time for the entire island.		
Egypt	Standard time is that of the thirtieth meridian east from Greenwich (eastern European time) and is therefore 2 hours fast of Greenwich or west European time and 1 hour fast of central European time. It is sent out electrically by the standard clock of the observatory to the citadel at Cairo, to Alexandria, Port Said, and Wadi Halfa.	7 0 0	Do.
Faroe Islands	See Denmark.		
Fiji Islands	See England.		
Formosa	See Japan.		
France	Legal time in France, Algeria, and Tunis is local mean time of the Paris observatory. Local mean time is considered as legal in other French colonies. This gives the following results:	5 9 21.0	Do.
	For Cochin China, Cambodia, and Anam (Saigon).	12 16 56	Do.
	Corsica	5 25 36.0	Do.

Country.	System of time in actual use.	Difference from Washington standard.	Earlier or later.
		h. m. s.	
France	Legal time in France, Algeria, etc.—Continued.		
	Guadeloupe	0 56 0.0	Later.
	Madagascar (Antananarivo)	8 10 7.0	Do.
	Marquesas Islands	3 39 0.5 to 3 45 7.0	Earlier.
	Martinique	0 55 16.0	Later.
	Mauritius	8 50 12.6	Do.
	Miquelon	1 15 16.0	Do.
	New Caledonia (Noumea)	16 5 48.0	Do.
	Paumotu Archipelago	3 19 12 to 4 54 54.4	Earlier.
	Senegal	3 50 18.0	Later.
	Tonkin	12 4 39.5	Do.
Germany	Legal time is mean solar time of longitude 15° east from Greenwich.	6 0 0	Do.
	In the colony of Kiautschou mean solar time of longitude 120° east from Greenwich is used.	13 0 0	Do.
	It is proposed to adopt standard time as follows:		
	For Togo, the meridian of Greenwich	5 0 0	Do.
	For Kamerun, 15° east	6 0 0	Do.
	For German East Africa, 30° east, or, possibly, 37½° east.	7 0 0 7 30 0	Do.
	For Bismarck Archipelago, New Guinea, Caroline and Mariana islands, 150° east.	15 0 0	Do.
	For Samoa, 180° east; but only after an understanding with the Government at Washington.	17 0 0	Do.
Gibraltar	See England.		
Greece	By royal decree of September 14, 1895, the time in common use is that of the mean time of Athens, which is transmitted from the observatory by telegraph every day to all towns.	6 34 53.7	Do.
Hawaiian Islands	See United States.		
Holland	The local time of Amsterdam (5^h 19^m 39^s later) is generally used, but Greenwich (5^h later) time is used by the post and telegraph administration and the railways and other transportation companies. The observatory at Leyden communicates the time twice a day to Amsterdam, The Hague, Rotterdam, and other cities, and the telegraph bureau at Amsterdam signals the time to all the other telegraph bureaus every morning. In the Grand Duchy of Luxemburg central European time is the legal and uniform time.	6 0	Do.
	Local mean time for the colonies gives for—		
	Java (Batavia)	12 7 20	Do.
	Sumatra (Padang)	11 41 20.9	Do.
	Iceland (Reikiavik)	3 32 20	Do.
Honduras	In Honduras the half hour nearest to the meridian of Tegucigalpa, longitude 87° 12′ west from Greenwich, is generally used; said hour is frequently determined at the national institute by means of a solar chronometer and communicated by telephone to the industrial school, where, in turn, it is indicated to the pubic by a steam whistle. The central telegraph office communicates it to the various suboffices of the Republic, whose clocks serve as a basis for the time of the villages, and in this manner an approximately uniform time is established throughout the Republic.	1 0 0	Earlier.
	For Belize, see England.		
Hongkong	See England.		
Iceland	See Denmark.		
India	See England.		
Italy	Mean solar time of the fifteenth meridian east from Greenwich is the standard time adopted by royal decree of August 10, 1893, for the Kingdom of Italy. This time is to be kept in all Government establishments, offices, dock yards, and is to be used by all ships of the Italian navy in the ports of or doing duty on the coast of Italy. All railroads, post and telegraph offices, and Italian coasting steamers are to use this time and regulate their business and time-tables in accordance therewith. The hours run from midnight to midnight—that is to say, in Italy 1 p. m. is thirteen hours, 5 p. m. is seventeen hours, etc.	6 0 0	Later.

Country.	System of time in actual use.	Difference from Washington standard.	Earlier or later.
		h. m. s.	
Jamaica	See England.		
Japan	Imperial ordinance No. 51 of 1886: "The meridian that passes through the observatory at Greenwich, England, shall be the zero (0) meridian. Longitude shall be counted from the above meridian east and west up to 180°, the east being positive and the west negative. From January 1, 1888, the time of the one hundred and thirty-fifth degree east longitude shall be the standard time of Japan."	14 0 0	Later.
	Imperial ordinance No. 167 of 1895: "The standard time hitherto used in Japan shall henceforth be called central standard time. The time of 120° east longitude shall be the standard time of Formosa, the Pescadores, the Yayeyama, and the Miyako groups, and shall be called western standard time. This ordinance shall take effect from the 1st of January, 1896."	13 0 0	Do.
Java	See Holland.		
Kamerun	See Germany.		
Karolines	Do.		
Kiautschau	Do.		
Korea	Tokyo time (135° east from Greenwich) is telegraphed daily to the Imperial Japanese post and telegraph office at Seoul.	14 0 0	Do.
	This is corrected by subtracting 30 minutes, which nearly represents the difference in longitude, and is then used by the railroads, street railways, and post and telegraph offices, and most of the better classes. In the country districts the people use sun dials to some extent.	13 30 0	Do.
Madagascar	See France.		
Malta	See England.		
Marquesas Islands	See France.		
Mariane Islands	See Germany.		
Mexico	The National astronomical observatory, of Tacubaya, regulates a pendulum twice a day, which marks the local mean time of the City of Mexico ($6^h\ 36^m\ 31.6^s$ west from Greenwich), and a signal is raised twice a week, at noon, upon the roof of the national palace, such signal being used to regulate the city's public clock. This signal, the clock at the central telegraph office, and the public clock on the cathedral serve as a basis for the time used commonly by the people. The general telegraph office transmits this time daily to all of its branch offices. Not every city in the country uses this time, however, as a local time, very imperfectly determined, is more commonly observed.	1 36 31.6	Earlier.
	The following railroad companies use standard City of Mexico time, corrected daily by telegraph: Central, Hidalgo, Xico, and San Rafael, National, Mexican. The Central Railroad corrects its time daily by means of the noon signal sent out from the Naval Observatory at Washington, converted into City of Mexico time, and by a similar signal from the observatory at St. Louis, Mo.		
Miquelon	See France.		
New Caledonia	Do.		
New Foundland	See England.		
New Guinea	See Germany.		
New Zealand	See England.		
Nicaragua	There is no Government observatory, but the meridian of Managua is governed by the time of Corinto, the longitude of which is 87° 12′ 81″ west from Greenwich, giving for Managua longitude 86° 17′ 30″. Managua time, thus ascertained, is issued to all public offices, railways, telegraph offices, and churches in a zone that extends from San Juan del Sur, latitude 11° 15′ 44″ north, to El Ocotal, latitude 12° 46′ north, and from El Castillo, longitude 84° 22′ 37″ west, to Corinto. The time of the Atlantic ports is usually obtained from the captains of ships.	0 45 10	Do.
Norway	See Sweden and Norway.		
Panama	The railroad company uses the local mean time of Colon, corrected by steamers' chronometers ($5^h\ 19^m\ 39^s$ west from Greenwich). The Central and South American Telegraph Company now cables seventy-fifth meridian time (75° west from Greenwich) daily from Washington, and this will probably be adopted as the standard.	0 19 39	Do.

Country.	System of time in actual use.	Difference from Washington standard.	Earlier or later.
		h. m. s.	
Panama Canal Zone	See United States.		
Paumotu archipelago	See France.		
Peru	There is no official time. Local mean time (0h 8m 9s earlier) is used in Lima and other places. The Oroya Railroad takes its time by telegraph from the noon signal at the naval school at Callao (0h 9m 3s earlier), which may be said to be the official time for Callao, Lima, and the whole of central Peru. The railroad from Mollendo to Lake Titicaca, in southern Peru, takes its time from ships in the Bay of Mollendo.		
Pescadores Islands	See Japan.		
Philippine Islands	See United States.		
Porto Rico	Do.		
Portugal	No late report received, but understood to use standard time of the Royal Observatory at Lisbon.	4 23 15.3	Later.
Russia	All telegraph stations use the time of Pulkowa, St. Petersburg (7h 1m 18.6s later). At railroad stations both local and Pulkowa time are given, from which it is to be inferred that for all local purposes local time is used. Local mean time for other cities gives for—		
	Nicolaeff	7 7 5.39	Do.
	Riga	6 36 22	Do.
	Irkutsk	11 57 15	Do.
	Vladivostok	13 47 33.5	Do.
Salvador	The Government has established a national observatory, which issues time on Wednesdays and Saturdays at 12 meridian to all public offices, telegraph offices, railways, etc., throughout the Republic. The observatory is at San Salvador.	0 56 36	Earlier.
Samoa	See Germany and United States.		
Santo Domingo	Local mean time is used, but there is no central observatory and no means of correcting the time. The time differs from that of naval vessels in these waters by about 30 minutes.	0 20 32	Later.
Senegal	See France.		
Siberia	See Russia. (Irkutsk and Vladivostok.)		
Singapore	See England.		
Straits Settlement	Do.		
South Africa	Do.		
Spain	Official time is mean time of the meridian of Greenwich, obtained from the Madrid Observatory. It is used by the railroad and telegraph companies and the people of Madrid and the provinces generally, in some of which, however, local time is still used for private matters.	5 0 0	Do.
Sumatra	See Holland.		
Servia	Central European time (longitude 15° east from Greenwich) is used by the railroads, telegraph companies, and the people generally. Clocks are regulated by telegraph from Budapest every day at noon.	6 0 0	Do.
Sweden and Norway	Central European time (15° east from Greenwich) is the standard. It is sent out daily by telegraph from the Stockholm Observatory. As far as is known it is used everywhere in daily life.	6 0 0	Do.
Switzerland	Central European time is at present the only legal time. It is sent out daily by telegraph from the Cantonal Observatory at Neuchatel.	6 0 0	Do.
Toga	See Germany.		
Tonkin	See France.		
Trinidad	See England.		
Tunis	See France.		
Turkey	Two kinds of time are used, i. e., Turkish (7h 0m 0s later) and eastern European time (6h 56m 53s later), the former for the natives and the latter for Europeans. The railroads generally use both, the latter for the actual running of trains and Turkish time-tables for the benefit of the natives. Standard Turkish time is used generally by the people, sunset being the base or beginning and 12 hours being added for a theoretical sunrise. The Government telegraph lines use Turkish time throughout the Empire and St. Sophie time (1h 47m 32s ahead of Paris) for telegrams sent out of the country.		

Country.	System of time in actual use.	Difference from Washington standard.	Earlier or later.
		h. m. s.	
United States	Standard time based on the meridian of Greenwich is universally used and is sent out daily by telegraph to all parts of the country and to Habana and Panama from the Naval Observatory at Washington (for the Pacific coast from the observatory at Mare Island Navy-Yard, Cal.). Standard times used are as follows:		
	For the Atlantic coast and Panama Canal Zone, eastern standard time, longitude 75° west.	0 0 0	
	For the Mississippi Valley, central standard time, longitude 90° west.	1 0 0	Earlier.
	For the Rocky Mountain region, mountain standard time, longitude 105° west.	2 0 0	Do.
	For the Pacific coast, Pacific standard time, longitude 120° west.	3 0 0	Do.
	For Sitka, Alaska standard time, longitude 135° west.	4 0 0	Do.
	For the Hawaiian Islands, Hawaiian standard time, longitude 157½° west.	5 30 0	Do.
	For Tutuila, Samoa, Samoan standard time, longitude 172½° west.	6 30 0	Do.
	For the island of Guam, Guam standard time, longitude 145° east.	14 30 0	Later.
	For the Philippine Islands, Philippine standard time, longitude 120° east.	13 0 0	Do.
	For Porto Rico, Atlantic standard time, longitude 60° west.	1 0 0	Do.
Uruguay	The time in common use for railways, telegraph companies, and the public in general is mean time of the meridian of the dome of the Metropolitan Church of Montevideo. The correct time is indicated by a striking clock in the tower of said church, with an approximate error of about a minute. An astronomical geodetic observatory, with meridian telescope and chronometers, has now been established and will fix the hour exactly. It is proposed to install a time ball for the benefit of navigators at the port of Montevideo. This electric time service will be extended throughout the country, using at first the meridian of the church and afterwards that of the National Observatory, when constructed.	1 15 11.1	Do.
Venezuela	The time is computed daily at the Caracas Observatory (longitude 66° 55′ 53.6″ west from Greenwich) from observations of the sun, and is occasionally telegraphed to other parts of Venezuela. The cathedral clock at Caracas is corrected by means of these observations. Railway time is at least 5 minutes later than that indicated by the cathedral clock, which is accepted as standard by the entire people. Some people take time from the observatory flag, which always falls at noon.	0 32 16.4	Do.

It will be seen from the above data that the majority of the civilized nations of the world have already adopted systems of standard time based upon the meridian of Greenwich, and it is very desirable, for the sake of uniformity and the convenience, accuracy, and simplicity of commerce and all other international relations, to have it adopted universally.

UNITED STATES NAVAL OBSERVATORY, WASHINGTON, D. C., SEPTEMBER 9, 1904

Following is a summary statement of the nations that use standard time, and the difference of their time from United States eastern standard time (seventy-fifth meridian west from Greenwich), from

data received by the superintendent of the United States Naval Observatory up to September 9, 1904, from the Department of State and Office of Naval Intelligence. Countries not named are understood generally to use local mean time.

Nation.	Basis of system of standard time.	Difference from United States eastern standard.	Earlier or later.
		h. m. s.	
Argentina	Cordoba	0 43 11.8	Later.
Austria-Hungary	Greenwich	6 0 0	Do.
Belgium	do	5 0 0	Do.
China (east coast)	Shanghai (Zikawei)	13 4 43.3	Do.
Colombia	Bogota	0 3 5.8	Do.
Costa Rica	San Jose	0 36 13.1	Earlier.
Cuba	Habana	0 28 50.4	Do.
Denmark	Greenwich	6 0 0	Later.
Ecuador	Quito	0 15 1.0	Earlier.
Egypt	Greenwich	7 0 0	Later.
England	do	5 0 0	Do.
Ireland	Dublin	4 34 38.9	Do.
Cape Colony, Transvaal, Orange River Colony, Rhodesia, Natal.	Greenwich	7 0 0	Do.
Straits Settlement	Singapore	11 55 25.0	Do.
West Australia	Greenwich	13 0 0	Do.
South Australia	do	14 30 0	Do.
New South Wales, Queensland, Tasmania, Victoria.	do	15 0 0	Do.
New Zealand	do	16 30 0	Do.
Alberta, Assiniboia, Athabasca	do	3 0 0	Earlier.
Keewatin, Manitoba	do	1 0 0	Do.
Montreal, New Brunswick, Ontario, Quebec.	do	0 0 0	
Nova Scotia and Prince Edward Island	do	1 0 0	Later.
Newfoundland	St. Johns	1 29 10.5	Do.
India and Ceylon	Madras	10 20 59.1	Do.
France, including Algeria and Tunis	Paris	5 9 21	Do.
Germany	Greenwich	6 0 0	Do.
Greece	Athens	6 34 53.7	Do.
Holland	Greenwich	5 0 0	Do.
Honduras	do	1 0 0	Earlier.
Italy	do	6 0 0	Later.
Japan	do	14 0 0	Do.
Formosa, Pescadores Islands, etc	do	13 0 0	Do.
Korea	do	14 0 0	Do.
Mexico	City of Mexico	1 36 31.6	Earlier.
Nicaragua	Managua	0 45 10	Do.
Panama	Greenwich	0 0 0	
Peru	Callao	0 9 3.0	Do.
Portugal	Lisbon	4 23 15.3	Later.
Russia (western)	Pulkowa	7 1 18.6	Do.
Salvador	San Salvador	0 56 36.0	Earlier.
Servia	Greenwich	6 0 0	Later.
Spain	do	5 0 0	Do.
Sweden and Norway	do	6 0 0	Do.
Switzerland	do	6 0 0	Do.
Turkey	do	7 0 0	Do.
United States:			
Eastern standard time	do	0 0 0	
Central standard time	do	1 0 0	Earlier.
Mountain standard time	do	2 0 0	Do.
Pacific standard time	do	3 0 0	Do.
Alaska standard time	do	4 0 0	Do.
Hawaiian standard time	do	5 30 0	Do.
Samoan standard time	do	6 30 0	Do.
Guam standard time	do	14 30 0	Later.
Philippine standard time	do	13 0 0	Do.
Porto Rico standard time	do	1 0 0	Do.
Uruguay	Montevideo	1 15 11.1	Do.
Venezuela	Caracas	0 32 16.4	Do.

TOPOGRAPHIC METHODS USED FOR THE NEW DETAIL MAPS OF THE GRAND CANYON OF THE COLORADO

By FRANÇOIS E. MATTHES, U. S. Geological Survey

[Abstract.]

Two atlas sheets comprising about 500 square miles in the Grand Canyon have recently been completed by the United States Geological Survey on a scale of $\frac{1}{48000}$ and with a contour interval of 50 feet. With the exception of the plateaus bordering the chasm, the entire area has been mapped by plane-table intersections taken from stations on the two rims. The peculiar topography of the Grand Canyon lent itself admirably to the intersection method. Indeed, it proved altogether unique in this respect, a thousand cuts from one station being by no means uncommon. The profuseness and intricacy of the details and the vast number of intersections they made necessary for the sketching precluded the use of such methods as are ordinarily employed by topographers for describing and recording cuts for future reference. Nor could any method be used in which the memory is in part relied upon in identifying points previously cut in. In the Grand Canyon hundreds of points were not located by intersection until more than a year after they had been cut in the first time. Again, the difficulties of drafting the extremely dense contouring on the often almost mathematically chiseled outlines of the so-called Temples rendered it necessary to evolve some method by which this laborious and time-robbing work could be done in the office without the great expense of maintaining a field party. The method adopted at the Grand Canyon fulfilled all the requirements, essentially through one and the same device. It may be termed the "preliminary sketch" method; and, while not new, it certainly has never before been applied on so extensive a scale and with so much systematic elaboration. The paper describes this method in detail and is accompanied by a series of sketches showing the successive steps in the work.

THE KAMMATOGRAPH

By HENRY WALLACH, London, England

The kammatograph, a photographic instrument invented by Kamm, of London, may be of particular value in work where it is essential to preserve records of moving objects, resembling those of the cinematograph. The great point in favor of the kammatograph, although it is not claimed that it produces the same results as the cumbersome cinematograph, is that it may easily be added to a traveler's outfit. The case measurements are: Height, 14 inches; breadth, 14½ inches, and width, 3½ inches; weight, 8 pounds. A similar case contains the glass plates, 12 inches in diameter. Observations may be taken at regular intervals extending over considerable time, provided the stop is inserted to shut off light. This glass plate contains about 500 pictures, which individually, if desired, may be enlarged by screening off the remainder of the plate. The usefulness of the kammatograph has been demonstrated by an English botanist, who has shown animated photographs of plants. Photographs of germinating seed were taken at regular intervals during many days, until the seed had germinated and sent up its seed leaves. These photographs can be thrown on the screen and the spectator can see the earth raised up by the swelling seed, the seed coat thrown off, the seed leaves emerge, straighten themselves out, and then the first leaves burst forth.

The same apparatus which takes the photographs projects them on the screen, by means of either electric or hydro-oxygen light.

MAPS: HANDLING, CLASSIFYING, CATALOGUING

By THOMAS LETTS

Having been unable to find any printed records relating, even indirectly, to the handling, classification, and cataloguing of maps, charts, and plans, it has appeared to me that a description of the methods adopted by the American Geographical Society and the reasons for their adoption might prove interesting if not instructive to this congress. At the outset I must at once disclaim any intention or desire to urge upon others the methods which we find practicable, as I am fully aware that in the internal organization of any institution there may be causes at work which might prevent or considerably modify the use of systems otherwise desirable.

I will treat my subject according to the three divisions just indicated: First, the handling; second, the classification or arrangement; and, third, the cataloguing.

Most librarians receive maps in three forms, i. e., (1) flat and unmounted (as issued by private or government institutions); (2) folded, either with or without protecting covers or cases, mounted on muslin or cloth, and sometimes dissected or cut up into sections, allowing them to be folded without detriment, and (3) on rollers, with ledges, generally mounted or backed with muslin, sometimes without either mounting or rollers, but at any rate as roller or rolled maps.

As to the classification, it may be conceded that the choice of a system—numerical, alphabetical, chronological, or topographical—is only a matter of personal preference so long as the catalogue entry corresponds with the map.

There are several very distinct groups into which sheet maps may be divided: First, the general collection of individual maps; second, sets of maps on a uniform scale of a country, a county, a parish, a city, or a town, each bearing its own series of numbers and system of identification, such as the various ordnance maps and plans of Great Britain and Ireland, Germany, France, Italy, Russia, etc.; third, charts on various scales, such as are issued by nearly every

European maritime country; fourth, maps periodically issued by governments or private publishers, covering given areas of country or groups of countries, such as the beautiful map of eastern Asia now being produced by the French "Service géographique de l'armée," on the scale of 16 miles to the inch, and others which are doubtless known to you; fifth, atlases, also published in parts whose issue extends over many years (as Stieler's Hand Atlas), which are always kept by themselves and are not mixed up with maps of the countries or parts of countries which they may represent; and in this last group the system of identification provided by the map makers is retained, as nothing would be gained by departing from such arrangement. Inasmuch as the individual map in every good atlas has a card for itself with its proper reference number, it can readily be found, whether unbound or bound.

The effort should be to place the individual map before the reader in as easy a form for reference as experience dictates, and this does not favor the binding of sheets in a book, which is not so convenient for consultation as the flat or sheet form. With these principles, therefore, to guide, sheet maps are arranged in manila paper wrappers chronologically as regards a particular country, alphabetically as regards the subdivisons of it, and all the countries of a continent are grouped together in A B C succession; thus the whole continent of America, North America, and Canada occupy tier No. 1 of our sheet cases, while No. 2 is assigned to the United States in general, followed by each State in A B C order, with Mexico and the West Indies in their places.

Now, in handling a sheet map, it is desirable as far as possible to avoid folding it. Every time a folding map is opened and closed it is weakened, and at last it cracks at the folds. It is obvious economy to have the map cut at the fold and a linen joint pasted up the back. This does not prevent the most critical examination of the finest workmanship, while it undoubtedly lengthens the life of the engraving.

Our cases or boxes for holding the sheet maps are made as long and as deep (from back to front) as can be conveniently handled. Their internal measurements are 41 inches in length by 27 inches deep (from back to front), and the height is 3 inches. The case is laid on a sliding frame, and once in place is not moved. It is opened by raising a hinged 5-inch lid, which allows the front to fall and leaves the box open. This arrangement gives the lightest possible receptacle with the greatest strength in the only part used—the hinge. It is found that a tier of 8 cases provides a good working top at a convenient height from the floor.

The particular pattern of case used has been found thoroughly sat-

isfactory in meeting all requirements, viz, facility of handling with a minimum of friction, and practical immunity from dust. Such a case has long been a desideratum in every office where maps and plans have to be preserved, and the evils attendant on the old methods of open shelves (sliding or fixed), drawers (with or without spring backs), curtains, or other devices for dropping fronts (recently introduced into the Library of Congress), portfolios of any kind (on movable racks or otherwise), need no longer trouble the long-suffering mortal who has had the care of maps and plans.

Of all forms in which printed documents can be presented to us, that of the bound book is undoubtedly the most convenient for consultation and for storing, and the nearer we can bring our maps to that condition, the better for the reader, the librarian, and the map itself. We all probably know from experience how difficult it is to keep track of sheets of paper, prints, drawings, plans, or maps. Maps should be dissected and mounted to fold as books; they can then be handled as books and need no special section of the map room to contain them. In like manner, if this class of map is presented to the library, preserve it as it is given and do not throw away its case and lay the map among your sheet stock.

With regard to rollers or rolled maps in any form, the system which most recommends itself is the following: Inclose and cover at top and front a long strip of wall, 12 inches deep from back to front, and of length to suit requirements; about 14 inches from the floor have a wooden framework made in the nature of a bottle rack or umbrella stand, in divisions of 12 inches square; and above it, about 42 inches from the floor, another framework of the same dimensions, but with the front opening on central points, to enable the rollers to be placed (not lifted) in or out.

These divisions can be made to answer to one or more letters of the alphabet, and the maps can be kept strictly in A B C order, as in the catalogue, and not according to countries, as the sheet maps, the quantity required being too small to justify the topographical arrangement.

Our society has adopted the chronological system, making the date or year of issue the main guide for arrangement. This may be illustrated by the boxes devoted to the State and city of New York. Maps of the State or large divisions thereof, not specifically named, are placed in chronological order and marked in pencil on the bottom right-hand corner with a date (an arbitrary one, if none can be found, and, of course, the same date on the card) and laid in one or more folios of strong manilla paper, averaging not more than 25 sheets, or equivalent thereto, in a folio, a single map folded in half being counted as two, the outside of the folio being marked to agree with the contents, as 1670–1720. These are arranged with the

oldest date at the bottom. If two or more maps bear the same date, descriptive information is added, as the name of the publisher or compiler.

It is a good plan to place the date in bold figures in the center of the wrapper. No matter how many maps are added, the chronological arrangement can always be preserved without alteration of the card until the box is filled.

Medium-sized collections of counties, townships, or cities are arranged alphabetically first and then chronologically, so that Albany City, Albion County, Black River canal, Black Rock village, and Buffalo all follow one another in the folio, and if there are two or three different dates to any subject they are arranged chronologically, the newer editions being at the top. In such a case as New York State, the city of New York has one or more folios to itself, and these maps are catalogued by themselves.

In taking up the subject of cataloguing, it is not to be understood that the practice of the American Geographical Society is necessarily recommended for adoption. It must be said, however, that cards with printed guides are admirably effective as compared with the older blank cards which called for no analysis of essential particulars.

These cards are printed especially to meet our requirements, and in practice have been found advantageous by confining the especial information desired to particular spots on the card.

----------------------------------	Section ----	Shelf ----
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--		
Place and publisher:	Date:	
Size within border:	Scale:	
Engraved	plain or col.	
Sheet		

The top line is left blank for the insertion of the name of the map or subject and the section or shelf to which it is assigned. The next four lines have been found sufficient to give the exact title, or such

general description as will complete identification in the absence of a title. Then follow the place, the publisher, and lastly the date. Now many maps give none of these particulars, in which case they must be supplied within brackets and with interrogation marks. Above all, a date of some sort must be given, as the whole plan of the system is based upon the chronological arrangement.

As to the question of size. This is a matter of great importance for identification and definition, and it should not be left open to question. The British Museum catalogue of maps omits size altogether. The catalogue of the Library of Congress says, "The measurements of the maps are in inches;" but, as a matter of fact, it does not say whether the measurement reads first horizontally or perpendicularly; nor does it say whether it includes the border, and consequently no correct mental picture of the map can be formed. The catalogue of the British Admiralty charts gives a table at the back of the title-page wherein it shows the abbreviations used for recognized sizes of paper, with their measurement in inches, but nothing is said as to how much of the paper is covered by the printed map, though, as a matter of fact, very little margin is wasted by this institution.

The catalogue of the United States Hydrographic Office, which supplies specially engraved copies of the charts of all nations for waters not within the jurisdiction of the United States, gives no indication of size, while the United States Coast and Geodetic Survey gives "size of border, — inches," but unfortunately adopts no uniform rule in its measurements, the first figure sometimes referring to the width across and sometimes to the height from top to bottom. In illustration I may refer to charts Nos. 119 and 120, pp. 41–43 in catalogue, 1903.

A catalogue description should be as concise and as correct as possible, and the facts given should be those best calculated to enable the consultant to identify the map by the description. In our society's catalogue the measurements always mean the map within the border, and they are to be read horizontally first, as we ordinarily read, and then perpendicularly. To emphasize this we affix to the measurements the arrowheads used on surveyors' and architects' plans →↓.

In preference to the metric system we have adopted inches for our standard, as more generally understood by our readers.

If the matter of size is important, the subject of "scale" must be regarded as the most vital feature of any map or chart; and yet even this has not been uniformly adopted in the British Museum catalogue or in that of the Library of Congress, though all three catalogues of charts to which I have already referred do state very clearly on what scale their work is engraved. The house of Perthes, in Gotha, was probably the first to mark on the table of contents the scale, not only of the main map, but also of the inset or subsidiary plans or maps,

and it is only now that other publishers are adopting the plan. It was a matter of considerable discussion as to what principle should guide us in the expression of scale, and while we finally adopted the interchangeable unit of miles to the inch, or the inch to the statute mile of $69\frac{1}{2}$ miles to 1 degree for maps, and the nautical mile of 60 miles to 1 degree for charts, we think it not unlikely that countries which do not use the Euglish language and measurements will prefer the fractional or decimal system of the proportion which the drawn map bears to nature, as $\frac{1}{63360}$ = 1 inch to the mile, or 1:63,360, an equation intelligible to the scientific of all nations.

Returning to the card: After the word "engraved" we add the words "on copper, wood, stone, steel, by wax process," as the case may be, and when possible the name of the engraver is added, as in the older maps that is often the only means of identification. If the map is a copy of a manuscript or one produced by photolithography or zincography, the fact is noted. Nearly all maps are primarily issued plain or uncolored, so that the word "plain" suffices to state the normal condition of the map; if, on the other hand, the map is colored, the words "by hand" or "printed in colors" are written in. The last line of all usually stands as printed, but frequently we add the sheet number, as in a series of charts, or folio number, if in an atlas, or mark it out and indicate the form in which the map is in stock, as "muslin, dissected to fold," "roller and varnished," etc.

The subject here outlined will be found treated in extenso in an article published in the Library Journal, volume 27, 1902, pages 74–76.

SUGGESTIONS WITH REGARD TO THE RÉCLUS SYSTEM OF MAP MAKING

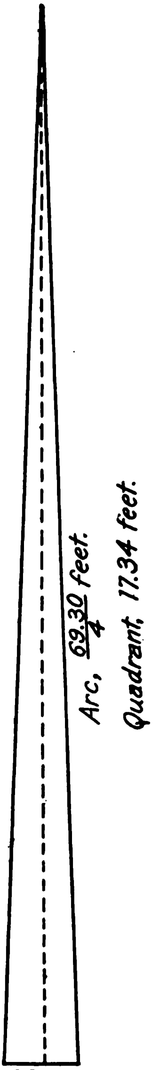
By PROF. RICHARD J. ANDERSON, M. D., M. A., Galway, Connaught, Ireland

Professor Réclus, of Brussels, pointed out some time ago that the formation of relief maps was based on a wrong principle. It has always been the rule to make the mountains unduly high in order to produce a proper impression on the eye, and in the case of ordinary flat maps the curvature of the globe can not be made clear, so that one can not have any correct notion with reference to relief or curvature. Réclus suggested the preparation of superficial sections of a globe sufficiently large to enable the constructor to make the mountains large enough to be easily seen, while they would maintain their proper proportions.

It is evident that by taking sufficiently large sections this can be done. If we take the highest mountains as 9,000 yards and compare with the circumference of the earth, 1 foot elevation corresponds to something less than a mile superficial length measured along a great circle. Such an elevation would be very easily seen, but the sections would be much too large. The measurement would be accurately 6 feet to 5 miles, or 1 foot to 6$\frac{2}{3}$ furlongs. An inch elevation representing the highest peaks would also be clearly seen. This would correspond to 0.55 furlong space; so that the highest peaks of the Himalayas and Andes would be very well seen even at a considerable distance on such a model. It would be possible to show the character of a considerable tract of country on the wall of a large room in this way, but obviously the size and unwieldiness would be prohibitive and, for obvious reasons, impossible with fragile material. Would it be possible to still further reduce the proportion without doing away with the distinctness of the relief? This could be done. An elevation of one-sixth of an inch can be easily appreciated. This would render it possible to display readily many hundred miles of country on the wall of a large room. Copper plates, however, would be im-

possible, or rather unwieldy. I have tried for the larger relief maps, which we obtain for geographical lectures, to make plaster casts and paper reliefs, with a fair amount of success. The paper was found to be far too bulky, and as an improvement it is suggested that paper sections be impressed for small areas, and afterwards jointed together, without strictly limiting oneself to the size. A strip 17.5 feet long, with 5-mile elevations figured at one-sixth of an inch, would be required to show the relief from the equator to the pole, but no one wants to see more than the aspect of a few hundred miles of country at once, and this will enable one to see 30 miles represented in one inch and 360 miles represented in 1 foot:

5 miles	⅙ inch.
30 miles	1 inch.
360 miles	1 foot.
3,600 miles	10 feet.



1 foot.

One foot represents 360 miles.

Circumference of model globe, 70 feet. Segments of this globe of convenient size might be used to receive the relief sheet.

Say, for example, that a strip was taken 1 foot in breadth at the base and 17.34 feet long. This would represent a breadth of 360 miles at the base, and if made to taper to a point at the pole would show the flat surface without the relief. By impressing in short lengths, the elevations may be stamped in, and the relief may be made to appear as distinct or much more distinct than in ordinary embossed note paper. If now the prepared section be applied to an arc of suitable curvature, the relative degree of curvature may be accurately obtained.

THE RELATIONS OF COMMERCE TO GEOGRAPHY

By O. P. AUSTIN, Washington, D. C.

[Abstract.]

The relations of commerce and geography have always been close and important. The earliest knowledge of geography was the result of explorations made in the interest of commerce, and this continued to be the case for many centuries. The commercial enterprises of the Phœnicians gave the earliest recorded geographical knowledge regarding the countries fronting upon the Mediterranean, and commercial explorations along the west of Europe and Africa contributed further geographical information. This was also true of the commercial explorations of the Greeks, while the contributions to geographical information by the Romans were divided between their military and commercial conquests. Commerce was also the moving cause in the work of the Venetians, who thus contributed much information regarding the geography of the then known world. It was commercial enterprise, the search for a route to India, which led to the discovery of America and the route to the Orient and southern Africa. Later the great commercial companies which developed trade with America, India, and the Orient, in turn gave to the world much definite and valuable geographical information. While in later years geographic research has been largely made in the interests of geography as a science, it has always been accompanied by an expansion of commerce. Thus commerce and geographical knowledge have always been cooperative and to a great degree interdependent, and this must be the relation of commerce and geography during the twentieth century. The section of the world in which they will be specifically called upon to operate and cooperate is that which is generally known as "the Tropics." The area lying between the thirtieth parallels of north and south latitudes contains one-half of the land area of the world and half its population, yet it now contributes but one-sixth of that which enters into international commerce. The great commercial and geographical work of the twentieth century should and will be to make this great area contribute its proper share

to the requirements of man—a task especially important in view of the rapidly increasing population of the world. Recent developments of science enable man to now overcome those natural obstacles which formerly prevented his subjugation of the Tropics, and this naturally most productive section of the earth, the Tropics, must now be peopled, developed, and required to supply its proper share of the requirements of the world's rapidly increasing population. Already the Temperate Zone has come to rely upon the Tropics for many of its requirements for food and manufacture, and this reliance is rapidly increasing. The Temperate-Zone nations have within recent years assumed control of most of the tropical sections of the world, and will now apply their energy and scientific knowledge to the development of that part of the world. In this work geography and commerce must cooperate. The geographical information already in hand regarding the Tropics will be required by commerce, and commerce in turn will supply to geographic science much information which it still lacks regarding this most important of the yet undeveloped sections of the world.

LA VALEUR ÉCONOMIQUE DE LA SUISSE

Par le Dr. ARTHUR DE CLAPARÈDE, Genève

[Résumé.]

La Suisse est un véritable paradoxe économique.

Pays pauvre, dans lequel les terrains improductifs occupent une superficie de plus de 28 pour cent du sol, sans posséder, sauf en ce qui concerne les fromages, aucunes des matières premières nécessaires à ses principales industries, la Suisse est parvenue à un développement industriel et commercial si élevé qu'elle occupe aujourd'hui le deuxième rang parmi les Etats d'Europe, pour le commerce extérieur, proportionnellement à la population du pays.

LA GÉOGRAPHIE ÉCONOMIQUE ET SOCIALE AU VINGTIÈME SIÈCLE

Par le Dr. ARTHUR DE CLAPARÈDE, Genève

[Résumé.]

La géographie économique et sociale, c'est-à-dire la géographie appliquée à l'étude de la production et de la circulation des richesses, ainsi que de l'état social des divers pays, occupe une place toujours plus considérable dans le champ de science géographique.

Inconnue pour ainsi dire il y a un demi-siècle—le nom même de géographie économique ne date que d'une trentaine d'années et celui de géographie sociale est encore plus récent—elle figure aujourd'hui au programme de la plupart des universités et son importance est destinée à s'accroître encore énormément au vingtième siècle, au fur et à mesure que se développent les moyens de communication, factures essentielles du mouvement économique et social de toutes les nations du monde.

SOME RECENT GOVERNMENTAL INFLUENCES UPON THE GEOGRAPHIC DISTRIBUTION OF COMMERCE

By Prof. EMORY R. JOHNSON, Philadelphia, Pa

Commerce consists of the exchange of commodities between or among separated areas of production. The commodities of commerce and the routes of trade change with the shifting of the areas and centers of production. The forces that determine where commodities shall be produced and used, and hence control the nature and the routes of the interregional exchange of goods which we call commerce, are numerous and more or less interdependent. They are industrial, political, and social, and, inasmuch as the object of productive effort is the satisfaction of human wants, the forces controlling commerce are also individual and psychical.

This paper is limited to a brief discussion of some of the recent political or governmental influences affecting the distribution of the world's commerce, and is concerned rather with the results of those influences than with an account of what the leading countries have done to develop and shift the centers and routes of commerce. The term "government" is used to include both central and local authority, and by "recent" is meant the period since the opening of the Suez Canal. The effects of the Suez waterway upon the geographic redistribution of the areas of production and the centers and routes of commerce were of such importance that a discussion of them would require a paper of greater length than this one.

The two areas having the greatest commerce are the United States and Europe, and the effects of governmental action upon the distribution of commerce may be pointed out by referring to what is being done by the United States and by the countries in Europe adjacent to the English Channel and the North Sea.

The commerce of the United States in the past has been characterized by two great trade movements: (1) The production of cotton in the South Atlantic and the Gulf States and the shipment of the staple to northwestern Europe and to the New England States; (2) the movement of traffic east and west between the States of the

upper half of the Mississippi Valley and the Atlantic seaboards of the United States and Europe.

The centers and routes of the cotton trade have not greatly changed during the past thirty years. Over half of the total product continues to be sent to Europe, and mainly by way of the seaports of the Southern States; but minor changes are taking place in the routes followed by the raw cotton, due, first, to the development of the railroads between the cotton belt and the industrial and commercial centers in the Northern States and the consequent shipment of a greater share of the raw cotton by rail instead of coastwise by water; second, to the growth of a market in Pacific countries for several hundred thousand bales of raw cotton, most of which is now carried by rail to the Pacific seaports of the United States; and, third, to the increasing manufacture of cotton goods in the Southern States, whose factories now contain nearly one-third of the spindles running in the United States.

The influence of government measures on the distribution of the cotton trade has not been important, although the three minor changes in that trade to which reference has just been made have been facilitated by the aid which the United States Government has given the companies that constructed the transcontinental railroads, by the improvements made in the Pacific coast harbors, and by the high tariff that has assisted the textile manufacturers in competing against foreign rivals for the American market.

The other great feature of American commerce—the trend of traffic east and west between the Central West and the North Atlantic seaboard—is becoming a less marked characteristic of the trade of the United States because of the growing commerce handled by way of the Gulf ports and the Pacific seaboard. During the past twenty-five years the United States has spent as many millions of dollars in improving the Gulf ports; and this fact, together with numerous other forces, chief among which have been the industrial development of the Southern States and the settlement and economic progress of the section of the country southwest of the Missouri River, has caused a great amount of capital to be expended in improving and increasing the railroad lines connecting the South Atlantic and Gulf ports of the United States with the great stretch of country extending from the Carolinas to Arizona.

Much has been said of the diversion of traffic from the North Atlantic ports to the Gulf gateways. What has really taken place has been less a diversion of trade than a growth of a new traffic. The North Atlantic and the southern ports have both increased their commerce, but the more rapid rate of growth has been in the trade of the Gulf cities. From 1890 to 1900 the tonnage of vessels entered and cleared at the Atlantic ports of the United States increased from

22,649,610 to 32,777,196 tons net register, a gain of 44.72 per cent. During the same period the entrances and clearances at the Gulf ports rose from 4,085,256 to 8,414,432 tons net register, an increase of 108.55 per cent. In other words, the shipping of the Atlantic ports increased less than one-half, while that of the Gulf section more than doubled.

The growth of the commerce of the Gulf ports is shown clearly in the following table, comparing the tonnage entered and cleared at the seven leading North Atlantic ports and the five most important Gulf ports for the years ended June 30, 1890, 1895, and 1900:

Tonnage of vessels entered and cleared at the seven leading North Atlantic ports and at the five leading Gulf ports, years ended June 30, 1890, 1895, and 1900.

Port.	1890.	1895.	Gain in five years.	1900.	Gain in ten years.	Gain in ten years.
North Atlantic ports:						*Per cent.*
Portland	260,796	250,312	0	716,001	455,205	174.54
Boston	2,613,335	3,115,478	502,143	4,145,187	1,531,852	58.62
New York	12,283,740	13,188,085	904,345	16,020,290	3,736,550	30.42
Philadelphia	2,530,094	2,711,434	181,340	3,736,615	1,206,521	47.69
Baltimore	1,969,501	1,608,257	0	3,452,654	1,483,153	75.31
Newport News	266,138	440,046	173,908	1,095,727	829,589	311.71
Norfolk	183,533	208,992	25,459	592,887	409,354	223.04
Total	20,107,137	21,522,604	1,415,467	29,759,361	9,652,224	48.00
Gulf ports:						
Port Tampa	9,080	174,466	165,376	208,595	199,515	2,197.30
Pensacola	815,778	703,380	(a)	1,115,382	299,604	36.73
Mobile	254,012	532,399	278,386	1,054,471	800,459	315.18
New Orleans	2,035,072	1,997,769	(a)	3,395,442	1,360,870	66.85
Galveston	343,575	767,629	424,054	1,538,300	1,194,725	347.73
Total	3,457,517	4,175,643	718,126	7,312,190	3,854,678	111.49

[a] Decrease.

From 1890 to 1900 the ports of Portland, Boston, New York, Philadelphia, Baltimore, Newport News, and Norfolk increased their total shipping 48 per cent; while Port Tampa, Pensacola, Mobile, New Orleans, and Galveston raised their aggregate entrances and clearances 111.49 per cent. The absolute gain of the vessel tonnage of the seven Atlantic ports named was two and one-half times the absolute increase of the tonnage of vessels that visited the five Gulf cities, but the percentage increase at the Gulf ports was two and one-third the percentage growth at the Atlantic cities. In the long run the percentage is more potential than the absolute gain. There is no probability that the Gulf cities will ever surpass the North Atlantic cities in the total volume of trade, but the redistribution of American trade now in progress will give the Gulf cities a greater share than they have had or now enjoy.

On the Pacific coast of the United States the most marked commercial progress has been made by the Puget Sound ports, of which the foreign trade rose from $6,206,456 to $25,051,670 in value during

the decade ending in 1900 and to $45,677,071 in 1903. The trade of Portland, Oreg., rose from less than $4,500,000 in 1890 to $10,000,000 in 1900 and to $13,000,000 in 1903. In both the Puget Sound and Portland sections the increase has been mainly in exports, but there has been a substantial progress in the volume of imports.

The most important port of the Pacific coast is San Francisco, the total foreign trade of which was usually over $80,000,000 a year during the decade preceding 1901. The growing population of California and the Rocky Mountain States has restricted the foreign exports of grain. The general economic progress of the State is developing the home market at the expense of the foreign, and the high prices which have recently prevailed in the United States for raw cotton, iron and steel, and many other commodities, together with the Boxer troubles and the war in the East, have temporarily checked the trade of both San Francisco and San Diego, but only temporarily. The better facilities for trade which the Government and the railroad corporations are giving the Pacific coast will enable California to resume her progress in foreign trade as soon as the present unfavorable conditions change, and that will be ere long.

The opening up of Alaska, the development of the wheat, lumber, and fishing industries of Oregon and Washington, and the phenomenal progress of the northern transcontinental railways in the United States, under the masterful guidance of James J. Hill, have combined to develop the more northerly Pacific ports of the United States with great rapidity. These northern ports are certain to continue their progress; but several industrial, commercial, and political forces are operating that will cause all the Pacific ports of the United States to advance rapidly. These forces may be summarized as the industrial progress of the western third of the United States, the growing commercial importance of all the countries bordering the Pacific Ocean, and the construction of the Panama Canal. The Government of the United States is systematically fostering the industrial progress of the great West, it is insisting on the open-trade door in the Pacific countries, it has acquired insular possessions in the Pacific, it is enlarging its Navy, and, what is most important of all, the construction of the Panama Canal has been begun.

By opening the Panama Canal the United States will exercise a wide-reaching influence upon the geographic distribution of the commerce of the world. The industries, the coastwise commerce, and both the import and export trade of the Gulf States and the western portion of the United States will be quickened into a growth even more rapid than that now prevailing. The economic benefits of the canal will be enjoyed by practically all sections of the United States—by the Northeastern States and the great Central West, as

well as by the southern and western portions of the country—and the larger commerce of the United States as a whole will, as the result of the Panama Canal, be so distributed as to give the Gulf and Pacific ports a larger share than they would otherwise secure of the enhanced total trade. In the long agitation to secure the construction of the Panama Canal by the United States Government, the people of the South and the far West have been the most urgent and persistent, and their demand for the new highway for the world's commerce was based on an intelligent appreciation of their own industrial and commercial interests.

The most significant facts regarding the recent development of the commerce of Europe are (1) the rapid growth of the trade of the continental ports along the English Channel and the North Sea, and (2) the increasing share that Hamburg, Rotterdam, and Antwerp have secured of the total commerce of those ports on the continent.

Although the British ports have greatly increased their trade since 1870, the north continental ports, with the exception of Havre, have made much more rapid gains. The absolute and percentage increase in the net-register tonnage of the entrances and clearances in the foreign trade at London, Liverpool, and the six most important English Channel-North Sea ports, from 1870 to 1900, inclusive, is shown with some detail in the following table taken from Dr. Kurt Wiedenfeld's valuable work on Die Nordwesteuropäischen Welthäfen, page 161:

Foreign commerce.

[1,000 net-register tons.]

	1870.	1880.	1890.	1897.	1898.	1899.	1900.	Increase, 1870-1900.	Per cent.
London:									
Entrances	4,089	5,970	7,709	9,111	9,438	9,438	9,581	5,492	134
Clearances	3,027	4,607	5,772	6,687	7,158	7,091	7,120	4,093	135
Total	7,116	10,577	13,481	15,798	16,596	16,529	16,701	9,585	135
Liverpool:									
Entrances	3,417	4,913	5,782	5,845	6,170	6,152	6,002	2,585	76
Clearances	3,356	4,746	5,159	5,416	5,998	5,666	5,666	2,310	69
Total	6,773	9,659	10,941	11,261	12,168	11,818	11,668	4,895	72
Hamburg:									
Entrances	1,604	2,767	5,203	6,708	7,354	7,766	8,038	6,434	401
Clearances	1,596	2,762	5,214	6,852	7,393	7,780	8,050	6,454	404
Total	3,200	5,529	10,417	13,560	14,747	15,546	16,088	12,888	403
Bremen:									
Entrances	655	1,169	1,734	2,259	2,465	2,407	2,494	1,839	281
Clearances	670	1,176	1,748	2,246	2,503	2,458	2,538	1,868	279
Total	1,325	2,345	3,482	4,505	4,968	4,865	5,032	3,707	280
Antwerp:									
Entrances	1,158	3,007	4,499	6,182	6,423	6,838	6,696	5,538	478
Clearances	1,124	2,975	4,523	6,132	6,483	6,736	6,670	5,546	493
Total	2,282	5,982	9,022	12,314	12,506	13,574	13,366	11,084	486

Foreign commerce—Continued.

	1870.	1880.	1890.	1897.	1898.	1899.	1900.	Increase, 1870–1900.	Per cent.
Rotterdam:									
Entrances	1,026	1,682	2,863	5,179	5,449	5,957	5,970	4,944	482
Clearances	1,070	1,686	2,891	4,991	5,310	5,828	5,763	4,693	439
Total	2,096	3,368	5,754	10,170	10,759	11,785	11,733	9,637	460
Amsterdam:									
Entrances	358	743	1,014	1,367	1,353	1,546	1,460	1,102	308
Clearances	356	720	1,054	1,434	1,391	1,596	1,512	1,156	324
Total	714	1,463	2,068	2,801	2,744	3,142	2,972	2,258	316
Havre:									
Entrances	1,206	1,979	2,159	2,221	2,292	2,176	2,136	930	77
Clearances	1,115	1,933	2,260	2,273	2,479	2,336	2,270	1,155	104
Total	2,312	3,912	4,419	4,494	4,771	4,512	4,406	2,085	90

In 1900 the total entrances and clearances at Hamburg were practically equal to the figures for London, and Hamburg's absolute gain since 1870 was 12,888,000 tons net register, as compared with an increment of 9,585,000 tons for London.. The percentage of growth during the thirty years was 135 for London and 403 for Hamburg.

The showing made by Rotterdam is equally impressive. Her total entrances and clearances increased 9,637,000 tons net register during the period—a greater amount than London's growth. The percentage of increase was 460.

The development of Antwerp's commerce has likewise been striking. Her absolute increase of 11,084,000 tons net register of entrances and clearances from 1870 to 1900 was surpassed only by Hamburg, while Antwerp's percentage of growth—486—exceeds that of any other port mentioned. It will be noted, however, that Antwerp made her most rapid strides from 1870 to 1890, and that while Antwerp's entrances and clearances have increased about 50 per cent from 1890 to 1900 Rotterdam's figures more than doubled during that decade. Likewise Hamburg's showing for the same decade is somewhat better than Antwerp's, for Hamburg's large tonnage total of nearly 10½ millions in 1890 increased at a more rapid rate per cent during the following ten years than did the figures for Antwerp.

Of the continental ports mentioned in the table Amsterdam and Havre have made the least progress. Amsterdam is being overshadowed by Rotterdam, which now has the better channel to the sea and has the great advantage of being directly on the great Rhine waterway, instead of being connected with that stream by a canal. Havre is gaining slowly, as compared with Antwerp, Rotterdam, and Hamburg. The port of Antwerp provides commercial facilities for an industrial region of great importance, while Antwerp and Rotterdam have the commerce of the Rhine River and valley, and Hamburg has the Elbe River and central and southern Germany for its hinterland.

The facts presented in the table warrant the general conclusion that the continental ports along the North Sea are increasing their commerce more rapidly than are the British ports, and that Hamburg, Rotterdam, and Antwerp, in the order named, are leading the continental ports in commercial progress.

The explanation of these two general facts regarding the shifting of the centers of commerce is not to be found in any single cause. The United Kingdom preceded the Continent in the development of her industries and commerce, and the continental countries are now engaged in catching up with their predecessor. To enable themselves to overtake their leader, they have adopted various measures to foster their industries and to facilitate their commerce, and they have done so with such success as to change the distribution of the world's trade and to place one of the countries in a position to threaten to secure the commercial leadership in Europe.

The commercial progress of Hamburg, Bremen, and the Dutch-Belgian ports has been due to the improvements of the Rhine and Elbe and to the extension of the navigation on other inland waterways more than to any other one cause. The railroads, it is true, have been so located and so managed under government control as to facilitate the commerce of the North Sea ports; but the cheap transportation by water, made possible by the Government, has been more influential than the railroads in building up the foreign trade of the north continental ports.

The maritime commerce of the continental ports, however, could not have had its rapid growth had not the harbors been provided with deep water and equipped with the facilities for handling and storing freight. To improve the channels connecting the ports with the sea, the government expenditures during recent years have amounted to $16,000,000 at Rotterdam, to $10,000,000 at Amsterdam, and to $12,500,000 at Bremen, and the Belgium State has expended large sums in improving the Scheldt. More has been spent in improving the harbors than in deepening the approaching channels. At Antwerp $25,000,000 have been spent on the harbor since 1879; at Rotterdam, $7,500,000; at Amsterdam, $10,500,000; at Bremen, $24,000,000; at Hamburg, $45,000,000, and at Stettin, $10,000,000. "Altogether it has been estimated that the several governments of Germany have devoted about $125,000,000 since 1888 toward the improvement of harbors, and that of this sum about six-tenths has been used for the channels and other facilities at Hamburg alone."[a]

Germany is the State having the most comprehensive commercial policy. The governments, national and local, provide the harbors and the channels to the ports; the inland waterways are constructed

[a] Huebner, Annals of the American Academy of Political and Social Science, Nov., 1904, Philadelphia, Pa.

by the States and operated with low tolls; the rates on the State railroads favor the industries and commerce of Germany more than those of other countries; there are mail and shipping subsidies of $1,750,000 paid annually to the lines engaged in the trade with Asia, Africa, and the East Indies; care is taken to strengthen the shipbuilding industry of the country; a strong navy is being developed; colonies are being established; and markets in many parts of the world are being secured.

It is not the purpose of this paper to describe the methods by which the continental States are fostering commerce, but rather to call attention to the successful results of their commercial policy. During the past quarter of a century there has been an enormous expansion of the commerce of Europe; and, for a large share of that trade, new centers and new routes have been established through governmental influence.

The facts here presented indicate that the growth of the commerce of the continental ports has been rapid as compared with that of the British ports, but do not indicate that the foreign trade of Great Britain is approaching its maximum. Having secured a preponderating share of the world's commerce, the ports of the United Kingdom have not, until within the last five or ten years, felt the need of spending great sums of money in enlarging and modernizing their facilities. While the adjacent countries of the continent, during the years from 1870 to 1890, were preparing to enter largely into the commerce of the world, the people of Great Britain were doing comparatively little to improve their commercial facilities, but now they are fully awake to the situation. Mainly by means of private capital, the harbors of Liverpool, Cardiff, Southampton, Glasgow, Leith, and many other British cities are being reconstructed, and now at last the great port of London is to be modernized. While the time is forever past when the trade of Europe is to center mainly in the ports of the British Isles, there is no reason to believe that the future expansion of British commerce will be less satisfactory than the future growth of the trade of continental Europe.

RISE AND DEVELOPMENT OF GERMAN COLONIAL POSSESSIONS

By GRAF VON PFEIL, Friedersdorf, Germany

It is impossible to review German colonization without a glance at German history. It is well known that during Hanseatic times our flag ruled the waves, but also that our former national tendency toward political discord and the Thirty Years' war sapped our political and economical strength to such a degree that when, shortly after that deplorable period, the partition of the Eastern world set in, we were not in a position to lend force to our demand for a share of it. The farsighted great elector of Brandenburg acquired colonial territories on the west coast of Africa, but was unable to keep them long for lack of political and financial power. The former was firmly established by the genius of Frederick the Great, and though his military achievements were, after his demise, for some time neutralized by the all-powerful Napoleon, the military power of Prussia remained her distinguishing feature. After the successful wars of 1864 and 1866 it led to the reunion of the various German tribes in one national empire, which in 1870 placed itself at the head of all the continental powers. Progress in the direction of finances was not slower. The steady growth of our industry created an increasing demand for its continually improving products in the world's markets and brought affluence to the economical life of the Empire. Our rapidly increasing population began to make us feel the necessity for national expansion. As we had no colonial possessions of our own, our surplus population emigrated chiefly to the United States of America, and if the inhabitants of this vast continent have achieved marvelous success in mercantile, scientific, and lately even in military lines, we attribute that circumstance with secret pride partly, at least, to the strong admixture of teutonic blood in your racial composition, derived from no less than 6,000,000 of German immigrants you received during the nineteenth century. This detrimental state of things, in which the surplus of our population went to enrich other nations, could not last; it caused the latent reminiscences of

Hanseatic times, of the Fugger and Welser, to awake, and with the example of England and the Netherlands before us, we endeavored to acquire colonial territories by private enterprise. We thus witness the astonishing fact that our first colonial possessions were acquired not only without the knowledge, but in some instances even against the wish of the Government. Southwest Africa was at first the private property of one merchant, and East Africa was taken possession of by the venturesome exploit of three young men, myself one of them. The form of administration of these our new colonial possessions we borrowed from the great English and Dutch charter companies of former times, whose manner of ruling we tried to adopt. The attempt proved impracticable. The country was all there, the people also, but there were neither healthy pasture or agricultural lands of any extent; there was no race of old culture with princes of fabulous wealth and there were no populous cities to become consumers of the products of our industry or fill our markets with the much-desired proceeds of their own handicraft or the products of their fields and forests. We found a race of indolent negroes, good-natured, but unable to develop the fertile regions they inhabit without being taught the lesson that life without certain necessities and comforts is penurious, even for a negro.

To inculcate that lesson was likely to involve considerable expenditure without promising reasonable returns. It is not, therefore, astonishing if our merchants were in no great hurry to take upon themselves this task, when more lucrative enterprises invited them to all other regions of the globe. Plantations seemed to hold out a fairer promise than educating the natives into the appreciation of shirts and trousers, and we began to turn our attention in that direction. The result was not encouraging owing to the wildness of the country and lack of experience regarding climate and soil. The difficulty of gaining the necessary information was augmented by the attitude the natives began to assume. The natives of perfectly wild countries look upon the whites as intruders, who have come to amuse themselves in some peculiar and inexplicable manner, and expect them to disappear some day as suddenly as they came. When they see that the white man means to stay for good and expects the black to render constantly those services which at first were tendered only from some sense of curiosity or desire of momentary gain, they retire into the remotest parts of their haunts, if they are of mild character, or, if of a warlike disposition, they try to shake off the unwelcome intruder. The latter treatment we first experienced in East Africa, and the latest instance of it, but hardly the last, is still seen in Southwest Africa.

When, through such hindrances our endeavors to govern the countries after the charter company system were frustrated, we were

obliged to introduce another method. This was rather forced upon than introduced by us. Our supremacy over the natives, and with it order, had to be established at all costs; and this task was intrusted to our officers. But our nation being prone to the precision of military rule, the administration of the colonies was left in the soldier's hands even when his military duty had been accomplished. Our faith in the great adaptability of our officers was not misplaced. The same exactitude which distinguishes their military drill was shown by them in civil administration. The lieutenant drew up invoices, collected taxes, built roads, and established regular communication between the stations in the interior and the coast. He taught the native to collect and deliver the products of the forest and gave him to understand that a firm hand had taken hold of the reins of government without a thought of ever relinquishing them again. Trade sprang up, laborers flocked to the stations, and after only a few years the merchant had to settle near the soldier again to relieve him of the traffic with the natives, which the soldier had called into life at the order of his commander and with no view of possible profit to himself. The native also is beginning to understand the advantages of the civilization he formerly eschewed, and he now trusts himself and his goods to the railway, which is considered such a success that the Reichstag has voted funds for the construction of another line in East Africa, so that within a comparatively short space of time that colony will be thrown open to a more energetic form of traffic and subsequently to the settlement of the European.

The above brief description of soldierly civil administration applies chiefly to our tropical African colonies, of which we have two others—Cameroon and Togo. These may almost be called Crown colonies, because they owe their origin to acts of the government, in whose hands administration lay from the beginning. The Cameroons might aptly be compared with East Africans with this difference only, that the natives there are great traders, who used to be so jealous of their trade monopoly that for a long time it was impossible to break the ring formed by the Duallas, who endeavored to intercept all communication with the people of the more remote districts in the highlands of the interior. Again the lieutenant opened the way. The Duallas, who offered armed opposition, were defeated and a flourishing trade with the hill tribes was established. Labor became cheap and plentiful, and on the plantations, which yearly increase in number, the fertile volcanic soil yields immense quantities of products, of which cocoa is daily more in demand. Togo is different in this respect—that the people are clever and hard-working agriculturists, who in time will no doubt work their own land on their own account. It is not at all unlikely that in some not very distant

future the life thread of that colony will be spun of cotton. It is a fact deserving notice that Togo requires no subsidies from the home treasury, the receipts balancing the expenditures.

New Guinea presents a very different state of affairs. Although this colony, like all others, had to leave the hands of the merchant to fall into those of the government, and although here man is still often looked upon only as a costly article of diet, the military system has not been introduced. We discover, on the contrary, a tendency toward the continuation of the charter system with modifications. No troops are stationed there, for the native disturbances, which sometimes happen by reason of the enmity of the tribes against one another, but which never exceed a narrow compass, are always speedily settled by one of our men-of-war. The interior is still a sealed book to us; all the business of the country is done in the way of trade, the staple article being copra. None the less plantations are increasing yearly and considerable quantities of coffee, rubber, tobacco, and other products are grown. New Guinea is the only one of our colonies in which large navigable rivers are found; their banks are densely populated. No doubt a bright future is in store for this colony. The island of New Pommern, nearly as volcanic as Java, is likely to prove as productive. The part called the Gazelle peninsula must be looked upon as the most advanced district in the whole colony, though its primeval forests and complicated mountain systems offer considerable difficulties to the extension of European influence. The natives, however, who formerly distrusted the white man, now flock to his settlements to work as laborers on the plantations.

The Solomon Islands, with the exception of Buka, are still practically closed to Europeans on account of the character of the handsome but ferocious natives, who in another century, however, will most likely be as useful and reliable as the present Fiji man, whose fathers were cannibals like the Solomon Islander of to-day. The Marshall and Caroline islands, in the South Sea, may be looked upon as trading stations for copra. Their area, taken singly, is too small and their soil too poor to offer room for any kind of plantation. The ample trade done there renders them valuable possessions. Administration is purely mercantile, and no troops are likely ever to be stationed there.

Let us see how our system answers in nontropical colonies. We have only one—Southwest Africa. Its physical aspect invites that class of settlers who have turned Cape Colony into one of the most valuable provinces of the English Empire. We can discern a close affinity between the physical characteristics of Southwest Africa and not alone the Cape, but all of the countries under the same latitude all around the globe. This resemblance justifies us in expecting for

Southwest Africa a course of development similar to that which is common to all the subtropical countries on the Southern Hemisphere, especially to that of the Cape, with which our colony shares the same class of inhabitants. The history of our colony, short as it is, proves the correctness of this surmise. When the first governor was sent out to the Cape, in 1642, the commercial expectations entertained by the old charter company were doomed to disappointment on account of the insignificant inducements the country offered to trade and agricultural pursuits. The settlers had to adopt the native mode of stock raising in preference to their own ideas of farming. When the settler began to encroach upon the natives' pasture lands, war was the natural consequence. We observe the same succession of events in our colony. Neither trade nor agriculture has yet proved very successful, whereas stock raising, although it is carried on in a rather desultory manner, answers very well. It was introduced by our military governors who had been intrusted with the pacification of the country. They studied the history of the Cape, and the lesson it taught they applied to the country they were called upon to administer. The settlement on grant farms of a number of troopers, who had served long enough in the country to familiarize themselves with the peculiarities of its climate and soil, must be considered a particularly able measure. The war, which is of no consequence, will soon be finished; it will then be our task to introduce methods of irrigation in order that those parts of the country that will admit of it may be turned into agricultural lands and worked by the settler whose chief capital consists in his strong hands and his willing mind.

We can not in our review pass over Samoa, which is a special feature in our colonial system, presenting the only instance where we have tried to rule natives through their own chiefs. At first we experienced difficulties, and had to banish one of the old chiefs to one of our other colonies. Later on we came to an understanding with him on terms which may be interpreted in this way: That he continues to rule over the mountain part of the island in a manner which leaves him responsible to the governor who resides in Apia, a good harbor and a handsome city in the agricultural parts. If in the African colonies the officer has achieved all success, it is chiefly due to the diplomat in Samoa. But success has here accompanied our steps as elsewhere, and the future of Samoa is assured.

There remains only Kiau Tschau, and I leave it an open question, to be decided by professors of international law, whether this place, held on lease from the Chinese, can be called a colony. Be that as it may, the success that has invariably attended our measures nowhere presents itself more strikingly. If in other colonies our military officers have earned their high repute as colonizers, Kiau Tschau, which is attached to our Admiralty instead of our colonial office, shows that

our naval officers are the equals of their comrades on shore. Only a few years back there was nothing but a shallow offing bordered by a number of dirty huts of poverty-stricken Chinamen and a range of hills denuded of all vegetation. To-day even fairly sized ships can tie up in a good harbor, a well-built and populous city for whites, and adjoining it a clean one for Chinese, is steadily creeping up the hillside, which is beginning to show signs of young forest growth. Trade is flourishing, and it is deserving of special notice that it has been possible to introduce a real-estate law which effectually stops all unhealthy speculation in landed property.

My short sketch has, I hope, shown you two things: First, that although the countries we took possession of can not be compared to the Indies, East or West, we yet succeeded in creating strongly pulsating economical life wherever we could earnestly devote ourselves to the administration of the country; secondly, that the acquisition of colonial possessions was merely the expression of a deep-seated national desire based upon historical reminiscences transmitted to us from Hanseatic times. To this strong feeling must be attributed our aptitude for colonial administration, of which we have given proof in the almost constant success which has attended nearly all our measures during the last ten years, and which is testified by the rapid growth of the economic development of all our colonial possessions.

THE ECONOMIC IMPORTANCE OF THE PLATEAUS IN TROPIC AMERICA

By Prof. J. R. SMITH, Philadelphia, Pa.

The plateaus and plains of tropic America offer an interesting paradox in their relation to the foreign commerce of those regions. The highlands are the chief seats of population; the lowlands are the natural, and, indeed, the only place for the production of most of the large and increasingly important list of staples for which the non-tropical regions depend upon the tropical. Here is a vast field for ethnic and industrial readjustment by which the people should relocate themselves where they can have access to the best resources.

A survey of that half of the American continent lying between the Rio Grande and the Rio de la Plata shows a topographic distribution of population that is the exact opposite of that prevailing in the temperate parts of the American hemisphere, in Europe, and in Asia. In North America the early colonists established themselves on the Atlantic plain, gradually worked up the valleys of the Atlantic rivers, and then westward into the basin of the Great Lakes, to the valley of the Mississippi and its northern extension, which is fast becoming the seat of empire upon the continent. Along the Pacific coast similar conditions are repeated. The valleys of California, Oregon, and Washington contain nearly all the population of those States, leaving large areas outside with very scanty population.

In Europe the dense populations are on the good lands of the great low plain extending from the Pyrenees to the Urals, and in the valleys of the Po, the Danube, and the British rivers. In Asia the great majority of the people, possibly nine-tenths of the population of the whole continent—half the people of the world—are crowded into the lowlands of the monsoon countries between the Indus and Manchuria and northern Japan. Upon these lands the summer monsoon rains make possible the growth of heavy summer crops. In overpopulated Japan agriculture is practically limited to a paltry 12 per cent of the land, a mere fringe around the edge of the mountainous isles, where irrigation can be secured from the mountain streams which flow across the narrow plains to the sea.

Throughout tropical America the centers of population are, with certain exceptions, upon the interior highlands, and 99 per cent of the vast area of lowlands skirting the two oceans, and sometimes reaching the interior of the continent, is unsettled, unused land. Instead of being the home of peoples, as in the temperate lands, it has always been a bar to settlement, and is to this day a hindrance or a prohibition to commerce and a vast land reserve of unknown possibilities for a more resourceful future to utilize.

In Mexico the geographers usually classify three zones—the cold, the temperate, and the hot, corresponding to the plateau, the slopes, and the low plains. Upon the first two are centered nine-tenths of the people. The plateau has in some sections a population as dense as that of France, and, considering its aridity, is really overpopulated, and the pressure of people upon subsistence is causing an alarming denudation of the rather scanty forest growth. Aside from the small seaport cities, the lowlands have a sparse population of wild Indians, lumbermen, and other workers in the forest. A few new plantations have also been started there, and this new work, in conjunction with recent railroad building, has created a demand for labor that can be met only by importing laborers from the plateau; and one of the present reforms of the Government is to stop the carrying away of the highland dwellers to involuntary servitude in the lowland forests.

Central America is still more pronouncedly a plateau country. The heavy rains from the trade winds give dense forests to the slopes and reduce much of the coastal plain to swampy jungle. The Atlantic plain being wider than the Pacific, the plateau between the double mountain ranges to the west was more easily reached from the latter ocean, from which it was settled and through whose ports its commerce was for more than three centuries almost exclusively carried on. In recent years coastal settlements along the Caribbean have grown through the rise of the banana industry, and Costa Rica and Guatemala have shifted a part of their commerce to the east through the opening of railroads to Caribbean ports; but on the whole Central America is still, economically speaking, a Pacific country, because the centers of population, being upon the plateau, lie nearer to that ocean and use it as their highway to the outside world.

The Pacific coast of South America shows in the main the same conditions. The marine plain from Panama to central Ecuador is wet, forest clad, and, except in some unwholesome parts, is populated entirely by a few wandering Indians. Ecuador consists of a fertile low plain, containing one-fourth of the population, and a high, isolated, and hilly plateau between the ranges of the Andes, upon which the remaining three-fourths of the people are crowded. Peru

presents a similar spectacle, with a comparatively dense population upon a plateau so high that at times men wear woolen masks to protect their faces from the cutting winds. The Peruvian coast lands have a greater development than any other in tropical America, owing to the aridity and healthfulness of the desert and a water supply from the Andes to support agriculture by irrigation.

In northern South America the outlying ramifications of the Andes mark the limits of the really peopled districts. Colombia, drained by the splendid Magdalena, uses that river as a means of communication between the seacoasts and the isolated plateau settlements, while the great valley lies almost untenanted. Venezuela has a similar condition, but fortunately her plateaus, centering around Caracas, are nearer the sea. The Orinoco, with tens and hundreds of thousands of square miles of grass and forest lands, has a few feeble settlements supplied by one trading steamer. This valley typifies the conditions of the interior of the South American continent. One of the world's greatest plains extends from the mouth of the Orinoco to the mouth of the Rio de la Plata and from the mouth of the Amazon to the foot of the Andes, a region that is double the area of the Mississippi Valley with its 40,000,000 people, or the Yangtse Kiang, with 150,000,000; but the South American land is a land unknown. In northern Argentina, even outside the tropic, large rivers have never been correctly charted, and in the Amazon Valley American commonwealths could be lost to the world if put down in the midst of unexplored reaches of jungle that extend to the base of the Andes. Only the larger streams have been navigated by native and Portuguese rubber gatherers and a few scientific expeditions.

In Brazil the center of population is on the plateau lying inland from Rio de Janeiro and Santos and on both sides of the Tropic of Capricorn. In this area is the center of the world's coffee production and the best-developed railway net to be found in the Torrid Zone. The elevation of the district, however, robs it of full tropical climate.

The coast of Brazil has the largest seaports of tropical America—Rio de Janeiro, Bahia, and Pernambuco. These cities are all on a coast swept by the trade winds, and, excepting Rio, which is the national capital and the port for a large interior district, each is the center of a producing district of small area lying close to the sea. In British Guiana this characteristic is more pointedly brought to attention, because nearly all the exports of this large colony are grown on a strip of alluvium diked and reclaimed from the sea after the manner of Holland. Furthermore, the coast settlements and cities from Rio de Janeiro to Guiana are largely populated by negroes or mulattoes, or, as in Guiana, by imported East Indian coolies.

The location of cities in tropical America shows forcibly the importance of the plateau. In temperate North America and in northern

Europe there is no national capital that is not located on a low plain, many of them are seaports, and all can be reached from the sea by at least river or canal navigation. In all tropical America there are 11 independent nations, excepting Panama, and of the 11 but 1, Brazil, has a capital city that is also a seaport. Even the Brazilian capital is not fully maritime, since the suburb of Petropolis, on the escarpment of the plateau, is the real administrative center, the residence of the diplomatic corps and the Brazilian aristocracy, and has also a growing textile industry.

The other 10 capitals of the American Tropics are beyond the reach of any kind of navigable connection with the ocean, and are usually situated upon plateaus from 2,000 to 9,000 feet in elevation, where good drainage and cool and wholesome climate prevail.

The colonies of Guiana and Belize do not enter into this comparison, because they possess no available plateaus for capital sites.

This centering of city as well as country life upon the plateau leads to a peculiarity of cities which may really be called a division of city functions. In the Temperate Zone every seaport develops in time into a considerable industrial center, the productive industries often supporting more of the population than the purely commercial. In the greater part of tropical America these two services are separated, and the city may be thought of as in two parts, one, the port, commercial, the other, upon the highland, industrial, administrative, and residential. In Costa Rica the capital, San Jose, has its port in Port Limon; Caracas has La Guiara and Puerto Cabello, and Lima has Callao. Santos, Brazil, with 20,000 people, is the greatest coffee port in the world and the port for São Paulo, a thriving plateau city with population of nearly 200,000. Each of these ports is much smaller than the city for which it is the outlet, the ratio ranging from about one-third to one-tenth, or even less, the City of Mexico having about 400,000 people, whereas the population of Vera Cruz does not exceed 30,000.

The economic effect of this predominance of the plateau is that the population is located on the least productive lands, and commerce is handicapped by the great difficulty of reaching the sea. This difficulty at times borders upon prohibition, and it is prohibition for commerce in any modern sense of the word. The upland dwellers of Ecuador, for example, numbering hundreds of thousands, possibly a million, and including the residents of the capital of the country, were, until the beginning of railroad work now in progress, dependent for connection with the outside world entirely upon a mule trail, where life and property were often threatened with destruction by slipping from narrow rocks to abysses below. Another part of this same trail crossed the lowlands, which the rainy season often made impassable even for pack animals. This case is extreme in the num-

ber of people dependent upon a single route; but it is fairly typical of the conditions that separate a large proportion of the people of tropical America from the world's highway, the ocean. As a natural result of this isolation many of these people have almost no foreign commerce whatever. The statement is not made that any single country has no foreign trade, for they all have; but each contains a considerable share of people who have almost no part in this trade and who live in houses of local construction, some without an iron nail in them, eat home-grown food entirely, and wear clothing of the meagerest pattern, possibly of homespun, possibly of imported cloth.

This economic isolation is indicated by an examination of the products exported from these regions, for imports must be paid for with exports. By classifying them in two lists, we may see the relative parts taken by the highlands and the lowlands.

EXPORTS FROM TROPICAL AMERICA

Plateau exports.—Coffee, ores and metals, hides, skins, wool.

Lowland exports.—Rubber, sugar, cocoa, bananas, cotton, tobacco, gold, asphalt, cinchona bark, cedar, mahogany, dyewoods, cabinet woods, spices, sarsaparilla, vanilla, indigo, cocoanuts, ivory nuts, brazil nuts, cochineal, fibers and bristles, cocaine and drugs, Panama hats, many miscellaneous articles in small quantities.

Staple tropical products imported by temperate peoples from Eastern Hemisphere.—Tea, rice, manila hemp, jute, varnish gums, pepper and other spices.

The plateau list is short, but is important in the volume and value of its articles. The lowland list is much longer, but no single article in it equals in importance the two leaders in the plateau column, coffee and minerals; yet as a group the lowland products are exceedingly important for modern commerce, and of great promise for the future. Only one of the plateau products, coffee, is really tropical, and it is not yet certain that its cultivation must be limited to plateaus. Some very suggestive experiments in coffee culture are being carried on at low elevations in Mexico. The ores and metals are natural mountain products in all climes, and the mountains in the countries under review are rich in minerals. The skins of cattle, goats, sheep, deer, and other wild animals are commodities of high value, good keeping qualities, and easy transport, and together with some wool they make up the most universal basis of export from the plateaus, and along with metals pay for the meager imports of those regions which are not so fortunate as to grow coffee. It thus appears that many of the people within the Torrid Zone are trading exclusively in nontropical produce, and that the large majority of the population, those upon the plateau, have probably a small majority of the commerce, including but one tropical product of importance.

There yet remains a long list of really tropical and lowland products, the ones we think of when the word "tropic" is spoken, rubber, cocoa, sugar, banana, mahogany, dyewoods, and all the roots, fruits, nuts, drugs, extracts, and products of the forest, the palm, and the cultivated field. These much-sought products give a greater per capita foreign trade to that small proportion of the population living in the lowlands. The growth of their population has not yet responded to the growth of their trade. Almost without exception, the natural and cultivated products of the American Tropics are in increasing demand in North America and Europe, where they are required as food or as raw materials of industry. Moreover, several staples of the Eastern Tropics may possibly, with proper industrial conditions, be cultivated in America, and rice certainly can be, although it is now imported by every country between Cape Horn and the Arctic Ocean.

The needs of the world commerce require the products that may be produced in the lowlands of tropical America. Can the population of these regions increase in number and industry to meet these demands? Under the present conditions it does not promise to do so, but there are at least two ways in which it may become possible—one is by the introduction of Asiatics, accustomed to similar climate. This policy the British have tried successfully in some of their colonies, but the independent countries of the American continent have not yet made a success of that method.

The other means of peopling these lands is by the application of science to eliminate the tropical diseases that are now so fatal to white men and harmful to others. This is a possibility which is just arising, but which may rediscover to us the New World during the present century. Most of the particularly troublesome and so-called contagious diseases are now explained as due to or transmitted by the activity of animal organisms of various kinds. Once the danger is known it may usually be averted by combating some insect or germ or by inoculating the person so that the germs have no effect. Within the memory of living men smallpox has declined from the position of the world's greatest plague to a second-rate disease, due only to carelessness. The germ of typhoid fever is known and with care the disease can be controlled and prevented. Millions of our contemporaries have followed the steps by which mosquitoes have been proved the guilty agents in the spread of the dread and mysterious yellow fever, and the disease has in places been stamped out completely. In the same way the sleeping sickness of Africa is now known to be due to a variety of the tsetse fly, and malaria, the bane of tropics and lowlands everywhere, is now explained by science as another of the insect-carried diseases. As medical science has just begun to systematically study these questions, it is fair to presume, in

the light of present progress, that the time is not far distant when it may be almost or quite as easy to keep free from disease in the Mexican plains, in the Amazon or the Magdalena Valley, as in the Mississippi Valley.

If such a condition is attained, it but remains to so organize lines of transportation that it will be easy to travel from the hot lands to the nearest section of plateau, and to so organize society and industry that the vacations for men and recreation and recuperation for women and children may be easily obtained upon some cool plateau, with which the Tropics abound. There the depressing effects of long-continued heat will be avoided. In this respect it will resemble the life in American cities, from which people migrate by the hundreds of thousands in the heated season.

If society and industry can be so organized, world population and world trade will experience a transformation of a magnitude witnessed but once before in the history of the world—the settlement and development of the Mississippi Valley. Millions of square miles of the most fertile land will be opened to the surplus populations of Europe and America, and, if need be, those of Asia also, and the seat of empire in the American Tropics, as in the Temperate Zone, will shift to its natural place on the shores of the sea and the banks of great rivers. The thorough application of science to tropical agriculture will make these lands most productive. World commerce will surge forward because of the production of commodities which can not be grown elsewhere and which are desired by men of all climes.

The present possibilities of production on these lands is no index for the future, because science has not yet been applied by these new populations.

THE ATLANTIC FERRY

By Capt. D. J. KENNELLY, London

Travel between the continents of Europe and America has assumed vast dimensions, for the Atlantic is daily crossed eastward and westward by an ever-growing number of people.

Corporations owning ocean grayhounds—as the swiftest steamships have come to be called—and those owning vessels of lesser speed continue to carry the traveler at a charge proportioned to the time occupied on the passage. But while the price of conveying the passenger across the Atlantic is thus governed by the speed at which he is carried, the like rule does not apply to cargo, which, whether carried at 25 knots per hour or at 12 is practically charged at one common rate. This custom involves a waste of energy obtained at a high cost, and is opposed to the ethics governing transportation. The practice arises from old conditions. Before the advent of the steamship on the Atlantic—say about the year 1840—the sailing vessel was employed primarily to carry cargo and secondarily to carry passengers, for in those days travel by sea was comparatively limited. From year to year since the steamship on the Atlantic has grown in size, in speed, and in comfort, and the passage in a regulated period of time has become generally established.

Thus the conditions of the sailing vessel about 1840 became reversed in the swifter steamship of 1860, whose dominant factor thereafter became and is now the passenger, while cargo takes the second place. The object of the sailing vessel was to deliver her cargo with all possible dispatch; to-day the object of the swift steamship is to deliver her passengers and mails with the least delay, and then her cargo. In the course of things the owner of the sailing ship became the owner of the steamship, who was and is still unable to divest himself of the old—and now, with the swift steamships, wasteful—method of carrying passengers and cargo together in one vessel.

It is for this cause, I venture to think, that the present body of owners of swift steamships will be the last to inaugurate the steamship of the future, which shall be confined to the carrying of pas-

sengers, mails, and express matter, and from which cargo shall be shut out, that being carried by the cargo steamer.

In proof of the determination to cling to the old method, I mention the latest effort for placing on the Atlantic the most advanced type of steamship for passenger transportation, namely, the Cunard liner just laid down at Wallsend-on-Tyne, having the following dimensions:

Length	feet	760
Breadth	do	87½
Depth	do	60
Speed	knots	25

with accommodation for 2,900 passengers. A speed of 25 knots is guaranteed, but the builders are of opinion that in favorable weather this vessel will steam much faster.

I am of opinion that this and her sister vessel, the latest factors in Atlantic transportation of passengers and cargo combined, will not have many successors, but will be followed by vessels having the highest rate of speed, devoted wholly to passenger business combined with mails and express matter. And I am fortified in this view by the fact that recently there have been placed on the Atlantic three steamships of large size, the *Cedric*, *Celtic*, and *Baltic*, the latter with a cargo-carrying capacity of about 28,000 tons and with accommodations for about 2,900 passengers, all these vessels having a working reduced speed of 17 knots per hour. The *Baltic* is 726 feet in length, or 34 feet less than the coming Cunarders.

Judging from the above, it seems apparent that a halt has been called to the speed of ships carrying passengers and cargo, and that the heavily subsidized effort of the Cunarders to maintain the superiority in speed, lost to the German steamship *Deutschland* and others, her followers, is probably a last effort for the maintenance on the Atlantic of combined cargo and passenger steam vessels.

Transportation on the land by high-speed railroad trains is confined to passengers, mails, and express matter, while freight (i. e., cargo) is carried by slower trains. This is in accord with economical principles, and it can not be doubted that the near future will see like methods adopted on the Atlantic, and, later, on the seas generally, as circumstances shall demand.

Experience has proved, and I think it is unquestioned, that the traveler very generally aims to reach his destination by the shortest sea route. Within my own lifetime the passage to India by the Cape of Good Hope became obsolete—that is, to the steamship. Two officers of my own service, Lieut. Thomas Weyhorn and Commander J. H. Wilson, succeeded in 1829, in the steamer *Hugh Lindsay*, built at Bombay, in conveying mails and passengers from that port to Suez, whence they were carried to Cairo by camels, and, later,

by horses and four-wheeled vehicles to Alexandria, and from Alexandria to London via the Mediterranean.

To-day the sea route to India is shortened by rail from France to Brindisi, and also Trieste, and thence by sea to Alexandria. In like manner the Panama Railroad serves a shortening purpose, and, with the Panama Canal, the passage around Cape Horn will become as obsolete as that of the Cape of Good Hope is now.

To shorten the sea passage from England to Ireland an expensive railroad was built to Holyhead, and to dispense with that short passage a submarine tunnel is projected. A submarine tunnel was projected from England to France and a distance of nearly 3 miles at either end was completed when England, from motives of policy, prohibited further work, to the regret of many who suffer at sea.

To shorten the journey on the Atlantic and on the sea generally by a prolongation of travel on the land is to accomplish a desideratum.

An Atlantic ferry between the nearest safe and open ports, always accessible and easy to enter, might have Galway or Milford Haven for the European terminal and Louisburg, Cape Breton, for the American terminal. The distance from Louisburg to Galway is 2,020 geographical miles and to Milford Haven 2,157 geographical miles. With Galway as the eastern terminal it would be necessary to transfer the train across the Irish Channel in steamers specially built for that service, probably of twin construction, for overcoming to a certain extent the rolling motion from the sea sometimes encountered in that channel. At present no vessel exists for the transfer of trains across the Irish Channel for the ordinary passenger traffic between England and Ireland, and, therefore, until Galway has been furnished with appropriate means for the conveyance of trains across the Channel Milford Haven, on the west coast of England, becomes the eastern terminal of the ferry, and as its distance from Louisburg is 2,157 miles the passage, at 25 knots per hour, would be made in about eighty-six to eighty-seven hours.

In the year 1874, while I was a fellow of the Institute of Naval Architects, I stated that before a lapse of many years vessels would cross the Atlantic at a speed of 25 knots per hour. It is common knowledge to-day that there are vessels for war purposes speeding at 30 knots per hour, and I may be pardoned for affirming that later this speed will be reached on the Atlantic by steamships of the Atlantic ferry.

I purposely abstain from burdening this paper with statistics which on all material points regarding Atlantic transportation were set forth in a booklet I published over three years ago. It is sufficient to say that the persons conveyed between Europe and America during the year 1903 numbered a total of 320,678, or about 1,033 persons for

each day of a six days' working week throughout the year. It is unnecessary to attempt an estimate of the increasing numbers that each year will travel by the ferry of the Atlantic. The number is enormous now, but when a short passage of eighty-seven hours at sea is assured, to be in the near future lowered to seventy-two hours, the additional number who will avail themselves of this rapid transit will stimulate others to cross to the other continent who hitherto have remained at home rather than submit to the painful ordeal of mal de mer.

For facility of navigation at high speed I would recommend that an international first-class steam light-ship be moored on the Newfoundland banks, south of the Virgin Rocks, in 18 fathoms of water, equipped with modern appliances of siren and wireless telegraphy. This vessel would also assist in policing the ferry route daily being traversed by the steamers, which would keep in touch with the light-ship and with each other from land to land.

LA RÉPARTITION DES FORCES PRODUCTIVES DE L'INDUSTRIE EN FRANCE

By E. LEVASSEUR, Paris

Sur l'invitation du président du groupe français de l'économie sociale à l'Exposition universelle de Saint-Louis, j'ai dressé deux cartes murales destinées à présenter un aperçu de la répartition des forces productives de l'industrie en France.

Je me propose de dire dans le présent mémoire sur quels éléments statistiques j'ai fondé mon travail et d'indiquer quelques-unes des raisons économiques du groupement des industries.

I

On sait que la population de la France a eu durant cette dernière moitié du dix-neuvième siècle une croissance lente, dont le taux a été presque constamment en diminnant: 37,783,170 habitants en 1851 et 38,961,945 de population domiciliée en 1901, suivant le recensement du 24 mars.[a]

Croissance et diminution ne se sont pas produites uniformément sur toute la surface du territoire, parce que la natalité, l'excédent des naissances sur les décès, l'émigration et l'immigration differènt d'un département à l'autre; d'où il résulte qu'il y a des régions dont la population a augmenté pendant qu'elle restait stationnaire ou qu'elle diminuait dans d'autres. Ainsi, de 1836 à 1861 le nombre des habitants s'était accru dans 65 départements, en tête desquels se plaçaient la Seine (accroissement de 30.4 par 1,000 habitants), les Bouches-du-Rhône (16.1), le Rhône (14.8), le Nord (10.8), la Loire (10.2), la Loire-Inférieure (9.2), la Corse (8.6), la Gironde (8 par 1,000), et elle avait décru dans 21 départements, Cantal (3.3 par 1,000), Basses-Alpes (3.1), Haute-Saône (3 par 1,000), etc.[b]

[a] La population s'était accrue en 1866 jusqu'à 38,192,064 (chiffre rectifié par l'addition des troupes d'Algérie et du Mexique), tant par l'accroissement même de la population que par l'annexion de la Savoie et du comté de Nice. La perte de l'Alsace-Lorraine et la mortalité pendant les années 1870 et 1871 l'avaient réduite à 36,102,921 habitants en 1872. L'accroissement moyen annuel par 1,000 habitants a été de 5.5 habitants de 1872 à 1876, périodé qui a donné le taux le plus élevé; mais il n'a été que de 4.1 de 1876 à 1881, de 3.3 de 1881 à 1886, de 0.65 de 1886 à 1891, de 0.90 de 1891 à 1896 et de 1.7 de 1896 à 1901. Le nombre 38,961,945 est sensiblement supérieur à celui qu'a donné le calcul de l'excédent des naissances sur les décès.

[b] Voir la Statistique annuelle du mouvement de la population, année 1901.

Certaines différences sont plus fortement marquées dans la seconde période trentenaire, celle de 1876–1901 que la Statistique générale de France a étudiée; pendant cette période l'augmentation totale est moindre. Elle ne s'est produite que dans 27 départements: au premier rang se trouvent la Seine (20.8 par 1,000 habitants), les Alpes-Maritimes, station de plaisance (17.6), le Territoire de Belfort (13.6), les Bouches-du-Rhône (12.8), Seine-et-Oise (10.3), le Nord (9.1), le Pas-de-Calais (8.2), Meurthe-et-Moselle (7.9 habitants par 1,000). Par contre, 50 départements sont en décroissance: le Lot (7.2 par 1,000 habitants), l'Orne (6.6), le Gers (6.3), les Basses-Alpes (6.2), l'Ariège (5.6 par 1,000 habitants), etc. La majorité des départements ont dû en partie leur croissance à un excédent de naissances; dans les Bouches-du-Rhône il y a eu un excédent de décès que l'immigration a comblé.

C'est principalement dans la France septentrionale, dans l'ancien Lyonnais (Lyon, Saint-Etienne), sur la côte méditerranéenne, à l'embouchure des grands fleuves que sont situés les départements en croissance.

Ce n'est pas qu'ils aient présenté plus de vides à remplir que les autres. Au contraire, ils figurent parmi ceux dont la densité est aujourd'hui et était depuis longtemps la plus forte. En effet, voici les douze départements qui, sous le rapport de la densité, occupaient les premiers et les derniers rangs en 1846:

Départements occupant les premiers rangs sous le rapport de la densité.

	En 1846.	En 1901.	Taux d'accroissement—pour cent de 1846 à 1901.
Seine	2,849	7,653	+168.6
Nord	199	323	+ 62.3
Rhône	196	295	+ 50.5
Seine-Inférieure	126	134	+ 6.3
Bas-Rhin	127	134	+ 6.3
Haut-Rhin	119	a 152	....
Pas-de-Calais	106	141	+ 33.0
Manche	102	(76)	− 28.9
Loire	95	135	+ 42.1
Somme	93	(86)	− 8.1
Finistère	91	110	+ 20.8
Côtes-du-Nord	91	(84)	− 8.3
Bouches-du-Rhône	(81)	140	+ 72.8
Seine-et-Oise	(85)	125	+ 47.0
Loire-Inférieure	(75)	95	+ 26.6
Meurthe-et-Moselle	(75)	92	+ 26.6
Gers	50	38	− 31.5
Côte-d'Or	45	41	− 9.7
Aube	44	41	− 7.3
Haute-Marne	42	36	− 16.6
Cher	41	47	+ 14.6
Loir-et-Cher	40	43	+ 7.5
Indre	37	42	+ 13.5
Landes	32	31	− 3.2
Corse	26	34	+ 30.7
Hautes-Alpes	24	19	− 25.2
Basses-Alpes	23	16	− 43.7
Lozère	18	25	+ 38.8
Savoie	18	41	....
Moyenne générale de la France	66.7	72.6	+ 8.8

a Territoire de Belfort.

Sur les douze départements qui avaient en 1901 la densité la plus forte, sept étaient déjà classés dans cette catégorie en 1846; trois (Bouches-du-Rhône, Seine-et-Oise, Loire-Inférieure) en approchaient; la Manche, déparment tout agricole, la Somme et le Calvados, départements mi-agricoles et mi-industriels, sont sortis de la catégorie, leur densité ayant diminué. Meurthe-et-Moselle est un département créé en 1870 dont la population a notablement augmenté.[a] Le Bas-Rhin et le Haut-Rhin ne font plus partie du territoire français. A l'exception des trois qui sont sortis de la première catégorie et dont deux (Manche et Côtes-du-Nord) sont agricoles, tous les autres ont accru leur densité; la population, déjà dense en 1846, a continué à s'y agglomérer. Ils faisaient déjà partie avant la révolution de 1789 de la région la plus peuplée de la France.[b]

Sur 71 villes ayant en 1901 plus de 30,000 habitants, 31 se trouvent dans les 12 départements de plus forte densité.

D'autre part, sur les 12 départements qui avaient en 1901 la plus faible densité, 11 appartenaient déjà à cette catégorie en 1846 et 7 ont perdu depuis cette date une partie de leur population. Sept de ces départements ont une natalité inférieure à la moyenne de la France, qui est elle-même très faible,[c] et les douze sont presque exclusivement agricoles.

Existe-t-il entre la densité croissante de la première catégorie et l'activité industrielle une relation que la statistique puisse constater?

II

Examinons d'abord le nombre des travailleurs. Le recensement des professions opéré en 1896 en fournit le détail. Il a enregistré 18,467,338 personnes, formant la population active (12,061,121 du sexe masculin, 6,382,658 du sexe féminin, 23,559 dont le sexe n'a pas été déclaré). Sur ce total, 8,430,059 appartenaient aux professions agricoles et forestières, 5,605,184 à l'industrie (226,815 aux industries extractives, 5,378,369 aux industries de transformation de la matière), 1,603,817 au commerce et à la banque, 712,611 à la manutention et aux transports, etc. Il y avait donc contre 100 personnes appartenant à l'agriculture 66.4 personnes appartenant à l'industrie.

Les départements qui avaient plus de 60,000 travailleurs employés dans l'industrie étaient au nombre de 22. Ce sont ceux qui sont

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[a] Meurthe-et-Moselle, 365,137 habitants en 1872 et 484,722 en 1901.

[b] Voir la carte de la densité de la population de la France en 1790 dans la Population française, par E. Levasseur, tome I, p. 225.

[c] La natalité moyenne de la France de 1891 à 1900 a été de 22.1 par 1,000 habitants. Or, la plupart des départements de très faible densité ont une natalité inférieure à la moyenne: Gers 14.5, Côte-d'Or 17.6, Aube 18.9, Haute-Marne 18.2, Cher 20.1, Indre 20.5, Loir-et-Cher 19.9, Landes 21.4, Basses-Alpes 21.7. La Corse a une natalité de 25.8, la Lozère de 26.9, les Hautes-Alpes de 24.4.—Statistique annuelle du mouvement de la population, année 1901, p. cxxii.

coloriés en rouge sur la carte murale de l'exposition et sur la petite carte annexée à ce mémoire. Nous en donnons la liste avec le nombre (exprimé en milliers d'unités) des travailleurs qui étaient employés dans l'industrie et dans l'agriculture (avec les forêts) et le rapport des deux catégories:

Départements.	Nombre de personnes employées dans—		Sur cent personnes employées dans l'agriculture, nombre de personnes employées dans l'industrie.
	L'agriculture (par milliers).	L'industrie (par milliers).	
Seine (Paris et banlieue)	28	813	2.903
Nord	134	460	343
Rhône	76	204	268
Seine-Inférieure	98	158	161
Pas-de-Calais	124	156	126
Loire	90	148	164
Somme	85	108	127
Bouches-du-Rhône	53	108	204
Seine-et-Oise	93	106	139
Isère	134	105	78
Gironde	189	101	55
Vosges	71	97	136
Aisne	86	95	110
Saône-et-Loire	173	85	48
Meurthe-et-Moselle	55	84	152
Loire-Inférieure	195	82	42
Oise	63	80	127
Marne	79	73	92
Maine-et-Loire	162	71	43
Ille-et-Vilaine	224	67	30
Ardennes	38	63	166
Gard	79	60	76

III

Les 12 départements à forte densité sont tous compris dans la liste de ceux qui occupent le plus de travailleurs de l'industrie, et ils se trouvent groupés à peu près dans le même ordre sur les deux tableaux.

C'est que l'industrie est une cause de densité. Dans une contrée exclusivement agricole le nombre des habitants est limité par l'étendue des terres cultivables combinée avec l'espèce de production et l'intensité de la culture; la densité d'un pays de pâturages est moindre que celle d'un pays de labour; celle d'un pays de céréales est moindre que celle de vignobles et surtout de jardins maraîchers; toutefois, quelque soit le mode d'exploitation, si la population n'a pas d'autre objet d'échange que les produits de son sol, elle ne peut multiplier au delà des subsistances. Une population industrielle n'est pas emprisonnée dans ce cercle; car elle peut augmenter presque indéfiniment sa production si elle trouve des capitaux pour produire et des débouchés pour vendre; et si elle augmente, elle achètera ses aliments avec le prix de ses produits vendus et avec les profits de son commerce; c'est ainsi que le département de la Seine agglomère sur 1 kilomètre carré 7.653 habitants qui y sont moins exposés aux disettes que les cultivateurs de certaines contrées agricoles.

Par contre, huit des départements qui ont la moindre densité se·

trouvent parmi les 25 départements qui comptent le moins de travailleurs de l'industrie.[a]

Les industries textiles en France sont celles qui occupent le plus de bras. C'est en général dans les départements déjà classés dans la première catégorie qu'elles sont le plus actives: le Nord, pour la laine, le lin et le coton; la Seine-Inférieure, pour le coton et la laine; les Vosges et la Loire, pour le coton; le Maine-et-Loire, pour le chanvre: le Rhône, la Loire et l'Isère, pour la soie; l'Aube et la Somme, pour la bonneterie; la Loire, la Haute-Loire, les Vosges, la Seine, pour la passementerie, la dentelle et la broderie.[b]

Nombre de personnes employées dans les départements où ce nombre est, pour l'industrie designée, supérieur à 2,000.

Départements.	Lin, chanvre, yute.	Coton.	Laine.	Soie.	Bonneterie.	Dentelles et broderies.	Passementerie.
Ain				8,751			
Aisne		5,605	9,401			6,339	
Ardennes		6,264					
Aube			7,397				
Territoire de Belfort					20,406		
Calvados		3,033					
Brôme				5,617			
Eure		6,103	2,796				
Gard				7,107			
Hérault			2,679				
Isère			4,390	25,445			
Loire		11,750		20,674		3,124	21,056
Haute-Loire						15,486	6,506
Maine-et-Loire	11,048						
Marne			14,218				
Mayenne	2,919	4,259					
Meurthe-et-Moselle		2,018					
Nord	57,491	16,599	93,590		2,583	5,369	2,827
Oise			3,189				
Orne		9,840					
Pas-de-Calais	3,163					9,348	
Puy-de-Dôme						2,937	
Rhône		8,453	3,557	36,691		9,029	
Haute-Saône		4,023					
Saône-et-Loire				4,751			
Sarthe	2,234						
Seine					2,257	10,101	7,425
Seine-Inférieure	2,000	35,749	10,145				
Somme	13,418		5,304		10,662		
Tarn			6,093				
Vosges		32,947				13,931	

IV

La contribution des patentes, quoique partant sur diverses catégories de personnes, fournit sur l'importance relative de l'industrie par département un renseignement qui mérite d'être relevé. Le montant total du principal de cette contribution a été de 89,467,000 francs en 1902, soit une moyenne départementale d'environ un million. Or, les

[a] Nombres exprimés par milliers: Indre (30 milliers, soit 42 par 100 agriculteurs), Loir-et-Cher (30, soit 37 par 100 agriculteurs), Landes (28, soit 21 par 100 agriculteurs), Gers (21, soit 22 par 100 agriculteurs), Corse (14, soit 22 par 100 agriculteurs), Lozère (6.6, soit 17 par 100 agriculteurs), Basses-Alpes (7.5, soit 20 par 100 agriculteurs), Hautes-Alpes (5.9, soit 16 par 100 agriculteurs).

[b] Indications spéciales sur les industries textiles.

départements qui dépassent ce niveau appartiennent tous à la région du Nord, du Lyonnais, à la côte méditerranéenne et à l'embouchure de la Garonne et à celle de la Loire.

Principal de la contribution des patentes.

	Millions de francs.
Seine	29.9
Nord	6.0
Rhône	3.4
Bouches-du-Rhône	3.1
Seine-Inférieure	2.7
Gironde	2.7
Pas-de-Calais	1.6
Seine-et-Oise	1.5
Loire	1.4
Loire-Inférieure	1.1
Marne	1.1
Hérault	1.1
Somme	1.0
Meurthe-et-Moselle	1.0
Alpes-Maritimes	1.0

V

La situation et l'importance des bassins houillers dépendent de la constitution géologique des terrains. La production de la houille est aussi un indice parce que beaucoup de grandes industries se fixent de préférence dans le voisinage de ces bassins pour avoir leur combustible à bon marché.

Voici cette production en 1901 dans les cinq principaux bassins:

	Tonnes (par milliers).
Nord et Pas-de-Calais	19,690
Loire	3,868
Gard	2,038
Tarn et Aveyron	1,851
Bourgogne et Nivernais (Saône-et-Loire, Nièvre)	1,556
Bourbonnais (Allier)	1,007

Les deux premiers sont situés, l'un dans la région manufacturière du nord, le troisième dans le Lyonnais.

VI

Quoique la production de la fonte de fer soit subordonnée à la présence du minerai ou de la houille, elle est également un indice. Sur les dix départements qui tenaient la tête en 1901, trois (Meurthe-et-Moselle, Nord, Pas-de-Calais) appartiennent à la région du nord; un (Loire-Inférieure) est à l'embouchure d'un grand fleuve.

Production de la fonte de fer en 1901 dans les dix principaux départements.

	Tonnes (par milliers).
Meurthe-et-Moselle	1,446
Nord	263
Saône-et-Loire	91
Pas-de-Calais	86
Landes	78
Gard	68
Loire-Inférieure	60
Haute-Marne	49
Isère	39
Lot-et-Garrone	30

VII

Un indice plus certain de l'importance de la grande industrie est l'emploi de la machine à vapeur, mesuré par le nombre de chevaux-vapeur. En 1901, les dix départements qui occupaient sous ce rapport les premiers rangs étaient:

	Nombre de chevaux-vapeur (par milliers).
Nord	368
Seine	182
Pas-de-Calais	126
Meurthe-et-Moselle	98
Loire	89
Seine-Inférieure	79
Vosges	64
Saône-et-Loire	59
Rhône	46
Bouches-du-Rhône	46
	1,157

Les dix départements qui occupaient les derniers rangs étaient:

Hautes-Alpes	0.2
Lozère	0.4
Corse	0.4
Basses-Alpes	0.8
Lot	1.2
Cantal	1.4
Gers	1.6
Hautes-Pyrénées	1.8
Pyrénées-Orientales	1.8
Corrèze	2.4
	12.0

Six des départements de la première catégorie sont dans la région du nord (et nord-ouest) deux (Loire et Rhône) dans le groupe lyonnais, un autre (Saône-et-Loire) lui est contigu, le dixième (Bouches-du-Rhône) est méditerranéen.

De la comparaison des statistiques il résulte que les départements qui ont le plus de machines à vapeur sont aussi ceux qui ont le plus de travailleurs. On peut même, remontant dans le passé, affirmer que les départements où le nombre des machines a le plus augmenté sont aussi, en général, ceux dont la population a le plus augmenté. En effet, les dix départements de la première catégorie en 1901 possédaient en 1836 282,000 chevaux-vapeur et 6,393,000 habitants, et en 1901, 1,157,000 chevaux-vapeur et 11,094,000 habitants. Au contraire, les dix départements qui occupent les derniers rangs relativement aux machines en 1901 avaient en 1836, 2,180 chevaux-vapeur et 2,209,000 habitants, en 1901, 12,000 chevaux-vapeur et 2,088,000 habitants.

Les dix départements qui avaient le plus de chevaux-vapeur en 1836.			Les dix départements qui avaient le moins de chevaux-vapeur en 1836.		
Départements.	Chevaux-vapeur (par milliers).	Population (par milliers).	Départements.	Chevaux-vapeur (par milliers).	Population (par milliers).
Nord	91	1,026	Hautes-Alpes	40	131
Seine	38	1,106	Hautes-Pyrénées	85	244
Loire	33	412	Cantal	152	262
Saône-et-Loire	27	538	Lot	187	287
Pas-de-Calais	24	664	Lozère	190	141
Seine-Inférieure	17	720	Basses-Alpes	207	159
Somme	13	552	Corse	261	207
Rhône	13	482	Pyrénées-Orientales	289	164
Aisne	13	527	Gers	349	312
Gard	11	366	Corrèze	420	302
	282	6,393		2,180	2,209

Ce résultat opposé à la théorie de Karl Marx sur l'élimination des ouvriers par la machine et la tendance de l'industrie totale à réduire le nombre des emplois est conforme à la logique: la machine appelle l'ouvrier. Dans une industrie en développement, plus le nombre et la force des machines augmentent, plus il faut de bras et d'intelligence pour employer la force qu'elles produisent. Ce qui est vrai, c'est que cette force mécanique augmente dans une plus forte proportion que la force humaine, mais elle ne la supprime pas: elle lui communique au contraire une beaucoup plus grande productivité et presque toujours elle lui procure une rémunération supérieure. Voila ce que l'expérience enseigne, sinon dans chaque cas particulier, du moins dans la très grande majorité des groupements manufacturiers, à l'étranger comme en France. Les faits contredisent ainsi le préjugé, encore trop répandu, que la machine chasse nécessairement l'ouvrier. Le nombre des chevaux-vapeur a plus que centuplé en un siècle dans les ateliers du monde civilisé, représentant l'énergie de centaines de millions de manœuvres, et cependant le nombre des ouvriers de ces ateliers s'est accru considérablement.

VIII

La Banque de France a des succursales dans tous les départements. Les escomptes mesurent, non pas exactment mais par approximation, le mouvement du commerce dans lequel les industriels ont une large part. Sans faire entrer en ligne de compte la Banque centrale à Paris, dont le montant des opérations en 1902 a été de 7,359,000, voici le chiffre des opérations des principales succursales:

	Millions de francs.
Lyon (Rhône)	808
Marseille (Bouches-du-Rhône)	685
Lille (Nord)	651
Le Havre (Seine-Inférieure)	591
Bordeaux (Gironde)	554
Nantes (Loire-Inférieure)	223
Nancy (Mourthe-et-Moselle)	208
Roubaix (Nord)	206
Reims (Marne)	183
Toulouse (Garonne)	161

Ce sont encore, à quelques exceptions près, les mêmes départements qui apparaissent.

IX

On oppose souvent l'agriculture à l'industrie. Des cultivateurs se plaignent de la désertion des campagnes et de l'attraction qu'exerce sur leurs ouvriers les hauts salaires des manufactures et les plaisirs des villes. En réalité, il y a plutôt solidarité qu'opposition entre la ferme et la fabrique. Plus est grand le nombre des citadins, industriels, commerçants et autres, plus les produits agricoles trouvent d'acheteurs et plus la terre acquiert de valeur. On peut s'en faire quelqu'idée par la contribution foncière sur la propriété non bâtie. Les dix départements qui en 1901 fournissaient le plus fort contingent étaient:

Contribution foncière (principal et centimes additionnels).

[Par millions de francs.]

Nord	7.5
Seine-et-Oise	6.4
Pas-de-Calais	6.2
Seine-et-Marne	5.9
Manche	5.8
Aisne	5.5
Somme	5.5
Hérault	5.3
Oise	5.2
Eure-et-Loir	4.7

La moitié de ce groupe se trouve dans la région industrielle du nord.

Il en est de même pour les dix départements qui ont produit le plus de blé en 1901.

[Millions d'hectolitres.]

Nord	2.7
Aisne	2.5
Pas-de-Calais	2.3
Seine-Inférieure	2.1
Seine-et-Marne	2.1
Vendée	2.1
Seine-et-Oise	2.0
Marne-et-Loire	2.0
Eure-et-Loir	2.0
Somme	.91

X

A l'aide des documents que nous venons de rassembler et qui se contrôlent les uns les autres par la diversité de leur provenance, nous pouvons tracer sur une carte l'esquisse de la distribution des forces productives de l'industrie en France.

Le groupe le plus important est celui de la France septentrionale qui s'étend en latitude des environs de Paris à la frontière belge, et en longitude de la Manche aux Vosges.

Paris, Lille, le Havre, Belfort sont les quatre grandes villes qui en marquent à peu près les extrémités. Paris et le département de la Seine, avec leurs industries très variées et leur production de luxe, occupent une position exceptionnelle et prépondérante dans ce groupe. Le département du Nord, foyer très actif d'industries textiles et d'industries que la houille alimente, se place au second rang; le Pas-de-Calais est en quelque sorte par son bassin houiller le prolongement du Département du Nord. Dans la Seine-Inférieure et dans la Somme, ce sont les industries textiles qui dominent; dans la Marne, la fabrication des lainages dont Reims est le centre; dans les Vosges, la filature et le tissage du coton; dans la Meurthe-et-Moselle, la métallurgie.

Cette région avait déjà la supériorité sur les autres avant 1789; moins cependant qu'aujourd'hui. Elle la devait à la qualité de son sol agricole qui facilitait la formation des capitaux; à son lin dans le nord, à son chanvre dans l'ouest, à la laine de ses moutons en Champagne, au faisceau de voies navigables du bassin de la Seine. Il faut ajouter: à l'activité industrielle d'une partie de ses habitants, que la richesse naturelle avait stimulée et qui à son tour avait développé cette richesse. Au dix-neuvième siècle, l'emploi de plus en plus général de la houille y a singulièrement favorisé le développement des industries métallurgiques et mécaniques; les usines se sont agglomérées sur les bassins houillers; la tendance universelle à la concentration de l'industrie dans la seconde moitié du siècle a été aussi propice à cette région.

Le second groupe est celui du Lyonnais que caractérise surtout l'industrie de la soie. Il se compose principalement des deux départe-

[illegible] that [illegible] they [illegible] The M. K[illegible] of it.

[illegible] Better [illegible] the [illegible] the [illegible] to [illegible] the [illegible] in the woods [illegible]

[illegible] West Indies [illegible]

[illegible] the United States [illegible] from [illegible]

[illegible] from Eng[illegible] offices and rich pension[illegible] which they [illegible] under British rule [illegible] grow [illegible] and it is no wo[illegible] in heaven, the [illegible] for their maintenance [illegible]

[illegible] maintained by a strong govern[illegible] and from the [illegible] British islands it is but a step [illegible] regions where there is no security [illegible] destroy the fruits of one's industry; [illegible] passions of men, stimulated and [illegible] where in the name of liberty [illegible] periodically minds and bodies [illegible] of [illegible] Under such a [illegible] dormant.

[illegible] Caribbean Sea— [illegible] government, [illegible] taxes; [illegible]

THE CARIBBEAN REGIONS AND THEIR RESOURCES

By FRANCIS C. NICHOLAS

The questions I have the honor of bringing before you relate to a region so vast that their full discussion would require volumes, and as the Caribbean has been well explored, I will endeavor to pass over what has been done, and well done, by others with a brief mention, and will attempt to bring before you data which may be of special interest and which may possibly have escaped particular observation.

Our maps and charts give ample, accurate, and valuable data concerning the countries and islands bordering on the Caribbean Sea. We are not dealing with a new country—the Caribbean regions are the oldest in American history. When the lands occupied by our beloved United States were all unknown, a shadow, as it were, on the horizon of exploration and progress, the Caribbean Sea was being eagerly traversed by the ships and expeditions of old Spain; and two generations later, when these prosperous lands of ours were being explored and feeble colonies were contending for a foothold among them, the Caribbean regions were developed and colonized and were pouring that stream of wealth into old Spain which made it the first among nations, only to wreck it with very abundance—with the excesses and the luxury which attended it. To-day all is changed around the Caribbean; the power of Spain has gone forever, and in its place is a worse dominion, characterized by oppression, deterioration, tyranny, and almost unchecked corruption.

The blue waters of the Caribbean gleam and glisten as before, fertile plains, trackless forests, cool uplands, lofty mountains, and pleasant islands offer as of old their wealth and their beauty, yet they remain desolate—beautiful in all that nature can give, repulsive in all that wars, tumults, and corruption can bring to curse the lands and habitations of man.

In the beautiful islands of the West Indies, where the stern rule of the British Crown Government taxes the life out of the soil and shiftless negroes live and grow in swarms, asking only to live and eat what they can get, and not caring how they are clothed, excusing

themselves on the ground that if they accumulate property "The Mr. King" will tax them out of it.

So where's dhe use, Marster? Better spen' dhe money an' have dhe good of him to-night. Dher'l be sunshine to warm dhe day to-morrow an' sumfthing to eat from somewhere. Dhere's wild yam in dhe woods and fish in dhe sea, an' dhe Mr. King him tax too much an' times is hard, sir, for true.

The negroes of the West Indies are physically a fine, sturdy race, excepting those who live in the cities, and their contention that taxes are overburdensome is not without reason. I am the owner of a small place in Jamaica, British West Indies, and am taxed at the rate of about 9 per cent on its actual value, while the governor of that small island receives a salary which compares favorably with that of the President of the United States, and at the end of his term retires with a pension equal to the salary of a chief justice, all charged to and payable from the revenues of the island. Generally from one to six retired governors receive pensions, and lieutenant-governors, secretaries, justices, and a horde of other officials, all sent from England, receive fat salaries during their terms of office and rich pensions when that term has expired, all charged to the island which they may have helped to govern. So it is in all the islands under British rule, where the salary and the pension lists grow apace; and it is no wonder that the sturdy negroes put their trust in God in heaven, the fish in the sea, and the wild yam in the fields for their maintenance and find it unprofitable to accumulate property.

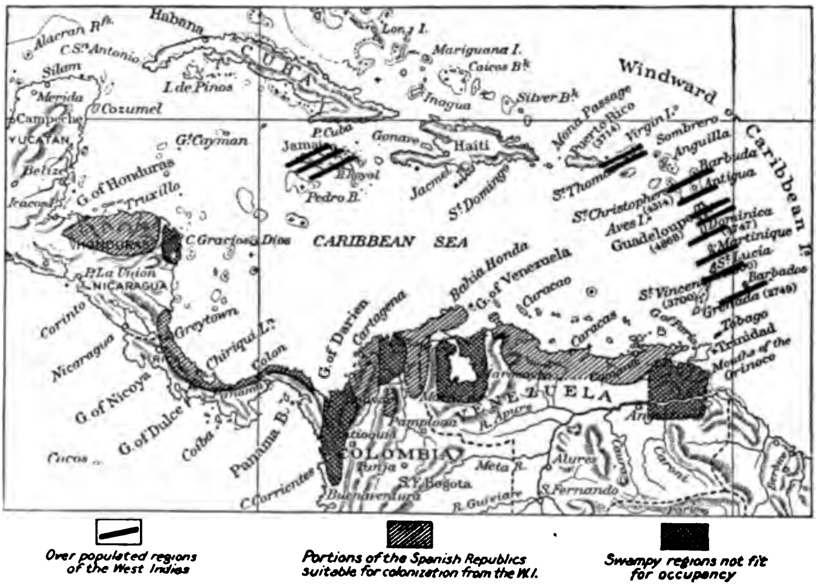
In the British West Indies order is maintained by a strong government; in the Spanish Republics it is different, and from the well-kept, well-groomed appearance of the British islands it is but a step, as it were, to the shiftless despair in regions where there is no security, and revolution and confiscation destroy the fruits of one's industry; and with them, the attending evil passions of men, stimulated and all unchecked, dominate those fair lands, where in the name of liberty every human excess is committed, and periodically minds and bodies inflamed by corruption rise in a tumult of civil war. Under such a system population does not increase, and wealth remains dormant.

These are the two great features of life about the Caribbean Sea—in the British West Indies the burdens of a ceremonious government, a teeming population, good order, and bitterly oppressive taxes; in the Spanish Republics anarchy at times, retrogression almost, continued insecurity, and a hopeless uncertainty. Out of these contrasting conditions will come the development of the Caribbean regions, for a teeming, sturdy population of the West Indies, native to the Tropics, is now seeking and will presently occupy in ever-increasing numbers the rich lands of the Spanish Republics and turn to the British Government for protection. Out of that protection order will be evolved.

Map No. 1 illustrates these conditions, the dark shading representing the overpopulated regions of the West Indies, the light shading portions of the Spanish Republics suitable for colonization from the West Indies; the portions unshaded representing the swampy regions not fit for any occupancy.

It must not be inferred that the white races from the North will have no participation in the redevelopment of the Caribbean regions; their influence and energy will everywhere give the power and the impulse, but the teeming population of the West Indies will supply the bone and muscle; but at a living wage—not for the 18 to 36 cents a day which most of the natives are now receiving.

The white races from the North will find in the Caribbean regions



MAP 1.—Population.

great stretches of upland country, easily accessible to the sea, possessing every advantage of climate and scenic beauty, with opportunities for the development of plantations which will be a permanent competence, for, once established, a tropical plantation may be considered permanent. It is as if our western grain fields, once brought to maturity, yielded their crops for years.

In map No. 2 the temperate regions suited to occupancy by white people from the North are indicated by shadings. Where the mountains are too rough for occupancy no shadings are made, the object of the map not being to locate climatic conditions, but to indicate uplands suited to occupancy by people from the North.

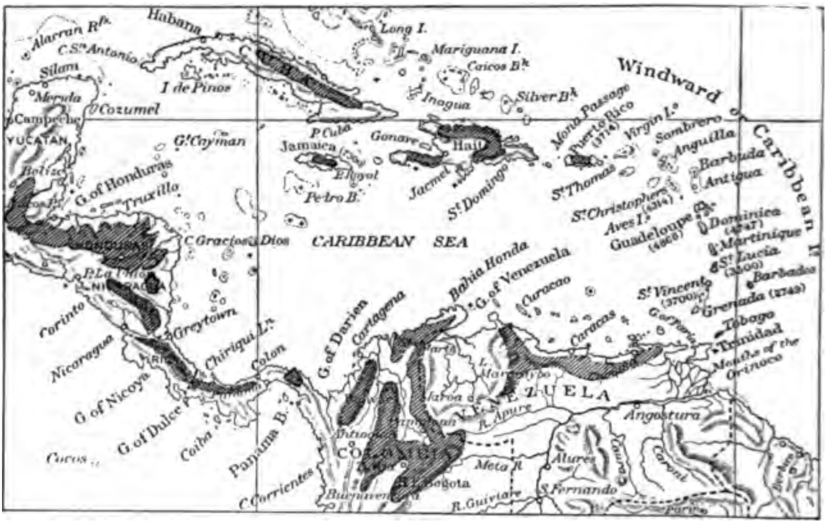
It does not follow that in only these regions can white people live;

throughout the Tropics people from the North have located, all are sustaining themselves, except only the dissipated; all are fairly comfortable, most are well to do, many are prosperous, and some are becoming very wealthy.

Among the people from the North intemperance is the most blighting of all evils. A company in which I am interested once sent an apparently respectable young man to take charge of a promising trading station in Colombia. This is one of his bills for drinks during two days:

January 14.—1 bottle claret, 6 bottles beer, 12 brandy cocktails, 3 vermouth, 3 brandies, 2 whiskies.

January 15.—6 brandy cocktails, 12 whiskies, 2 bottles claret, 13 brandies, 5 curaçaos, 12 bottles beer, 2 gins.



MAP 2. The heavy shadings represent temperate regions suited to white people from the North.

So the account goes on till our young man left the country, I am told, very much the worse for his experience, a grievous failure, for under such excesses no one can live in the Tropics—and from this it can be inferred that throughout the Caribbean regions there are other grievous failures. Unfortunately they are many, but in spite of this shameful exhibition the writer claims that men who will be men and conduct themselves with some regard for decency can live and prosper in the Tropics. We hear very much of the fevers of the Caribbean regions, but even yellow fever, the greatest scourge in the Tropics, is not so much to be dreaded in those regions as the stealthy pneumonia of the frosty North.

Not all the regions around the Caribbean Sea are healthful, and at some places swamps are forbidding and dangerous to health, at

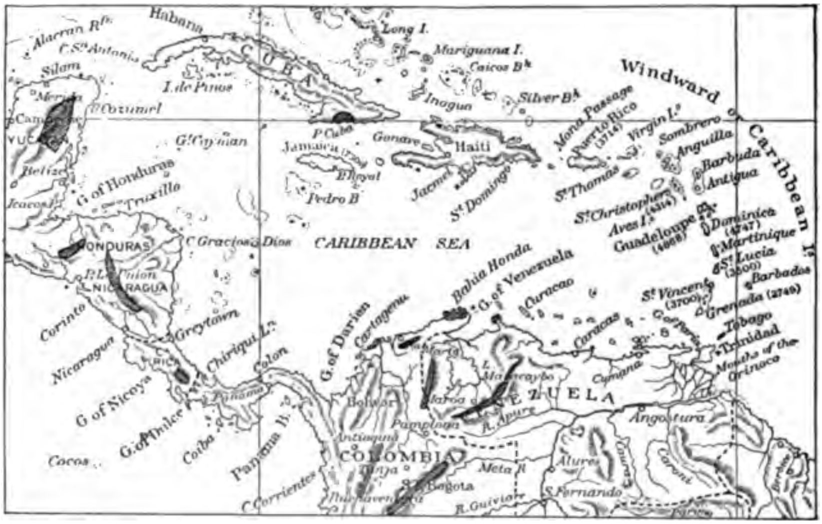
others the country is barren, rocky, and desolate, too hot and arid for man to occupy and preserve good health.

Maps 3 and 4 show barren and swamp regions.

Of the products from the Tropics four classes can be made:

1. Plantation products.
2. Products from cattle ranches.
3. Forestry products.
4. Mineral products.

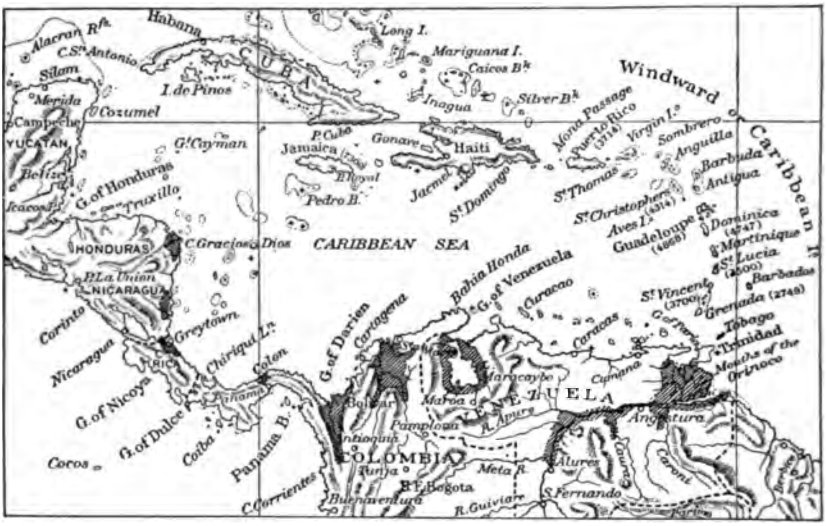
The different points where these products are to be had are indicated in the following series of maps by lines of shading. Where the lines are heavy they indicate regions where the product is obtained in abundance, while light shadings indicate unoccupied or only partially occupied regions where the product can be successfully developed or where such development can be reasonably assured.



MAP 3. —Barren or very rough mountainous regions are represented by heavy shadings.

The regions where all these products are to be had are just beyond our southern harbors. A tour along their coasts would open to view countries and lands of divers appearances. Should one begin at the western portion of Cuba and go eastward one would see the low coastal swamps of that island, with plains and thickets beyond them, and rising from these plains ranges of irregular hills and mountains in the interior. Farther to the east one would notice the flat lands of the middle portions of the island, where grassy plain succeeds grassy plain, and groups of palms in monotonous similarity rise one after the other as if there would be no end, though farther on the brown and green hills of Santa Clara would be seen in graceful outlines on the horizon, swelling up till the rugged mountains of Trinidad stand in

bold outline. Then the green mangrove islands dotting the placid sea of the south coast—green islands, placid waters, coastal plains, and rising mountains extending to Cabo Cruz. Then, rounding the cape, the rough, open sea, a rugged limestone coast, and the higher mountains of Santiago province; then the terraced formations of Cape Maisi, attesting the Antillean uplifts, and beyond the flowing waves of the Windward Passage. Southwest the island of Jamaica, green and fertile, rises abruptly from the gleaming Caribbean: tall mountains, broken ridges, a wilderness of glades, valleys, and rolling plains; and the splashing of many waters mingles with the sound of the sweeping winds and the melancholy cadence of the songs of the negroes at their labors.



MAP 4.—Heavy shadings represent regions of deep swamps or low marshes near the sea.

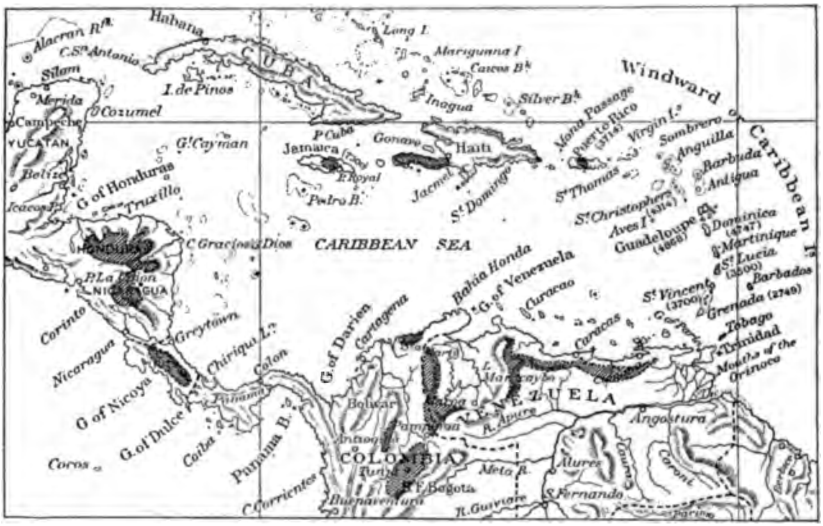
To the east of the Windward Passage lie the fertile but blighted lands of Haiti and Santo Domingo, seeming a dream of placid beauty—mountains, valleys, and fertile uplands—as one approaches, succeeded by a rude awakening when the traveler stands to view the squalor, the disorder, and the evil of political and social conditions which make of this beautiful island a blot on the fair face of the Caribbean and a reproach to the civilized world. Farther to the eastward, beyond the Mona Passage, is the sturdy island of Porto Rico, where swelling hills and green uplands charm in pleasing prospect; a land of promise, but not yet adjusted to altered political conditions. Then to the southeast lie the rugged shores, tabled formations, and sharp outlines of the Leeward Islands, and farther to the south the volcanic peaks and rough contours of Guadeloupe, St. Lucia, and St. Vincent, gems of green and frowning gray, rising

from the bluest waters to be found in all America and dulled by the iridescent gleaming of the sunshine on the intense blue of the surrounding ocean. To the eastward is the low wind-swept island of Barbados, with its fertile fields and teeming population, and bending to the westward the chain of islands extends to the fertile island of Trinidad, its green fields, shady forests, and gray moss-grown rocks facing yellow waters which attest the mighty volume of the Oronoco, pouring into the sea south of Trinidad, silting up and ever building outward the treacherous shores of its delta, where jungles, swamps, and muddy plains of marsh lands mark the outpourings of a mighty river which has gathered together the waters of a vast region, even to the remote unknown lands of the interior of South America.

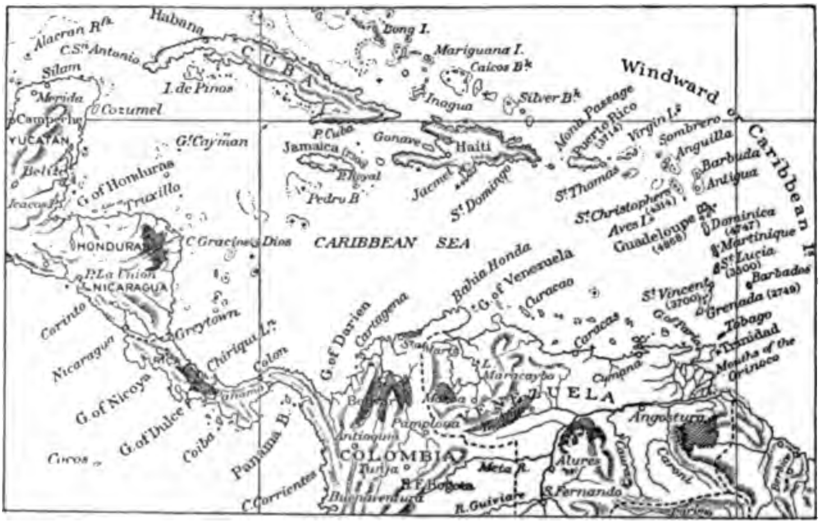
Sweeping away to the westward are all the lands and mountains of the Spanish Main, regions of romantic history, of deeds of blood and of oppression. Here are the coast lands of the Republic of Venezuela; fertile hills, broad valleys, and prominent mountains extending to the deep embayments and coastal plains of Maracaibo; with the low, rugged islands of the Dutch West Indies, rocky havens of security just beyond the turmoil, corruption, and the untold wealth of Venezuela. Still farther westward lie the green plains and brown barren hills of the Goajira country, where a race of sturdy Indians maintain themselves and their fair land in semiindependence; and adjoining on the west is the strange valley of the Rio Hacha country, extending back to the interior from a barren, sandy plain—a region but little known, where there is every indication that here there was once the mouth of a great waterway from the interior, and in the sedimentary formations a wealth of minerals, coal, hydrocarbon, and other products are indicated: a region where, to the southeast, some miles up the valley, the awe-inspiring formations of the Painted Andes rise in strange, bold precipices painted with great alternate bands of intense black and shining white frowning above the verdure of the rising foothills and lower mountains, great bands poised in the air, as it were, above the valley. To the west of the Rio Hacha country are the Sierra Nevada de Santa Marta Mountains, rising from the blue waters of the Caribbean and towering to the sublime heights of perpetual snow—a region where scenic grandeur can scarce be rivaled in all the world, where fertile valleys, grassy slopes, frowning precipices, and towering mountains lie supremely beautiful below snow-capped peaks, the monarchs of the Caribbean regions, towering into the silence of the upper air, clothed in the glistening white and cerulean blue of perpetual ice and snow. In this region the remains of a former race attest the occupancy of teeming thousands who lived and were prosperous; and the land is destined at some future day again to support its hundreds of thousands of prosperous people.

Farther west the swamps of the delta of Magdalena River are seen, where a torrent of water comes down to the sea from regions stretching hundreds of miles into the interior and extending to lands where wealth incalculable is awaiting development. Westward from the mouth of the Magdalena are the low hills, plains, and barren ridges of the Cartagena country, and still farther westward is the Gulf of Darien and the swamps and lowlands of Atrato River, gray in a clinging mist and deluges of rain, uninhabitable and desolate, stretching far to the south to the gold fields of the Choco country, where only disaster succeeding disaster has followed those who have sought to win its golden wealth.

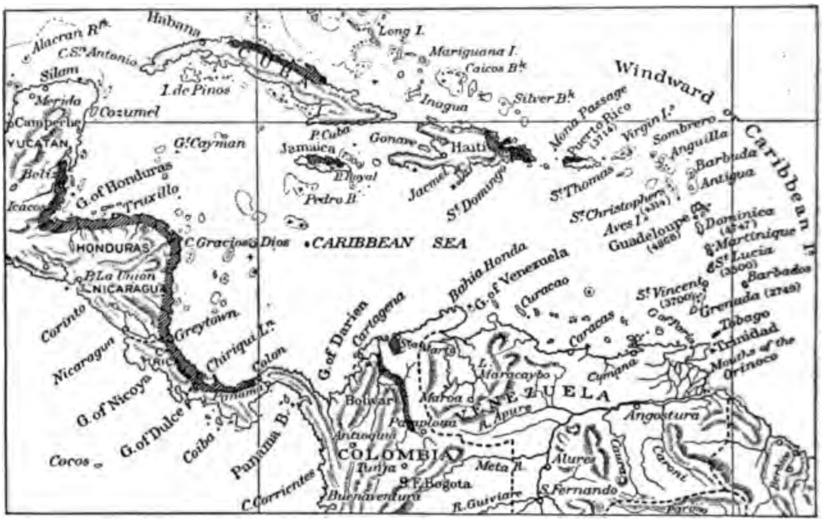
Then the shores of the Caribbean turn northward to the misty regions of Panama, and high mountains lie dark on the horizon. First the uninhabited and little-known regions of the lower San Blas country; then the San Blas Islands and coasts, populated by Indians and fringed with cocoanut trees; then the low divide where green hills and coastal swamps mark the site soon to be the busy scene of canal construction. Farther north higher mountains again and the pleasant lagoons of the Chiriqui country; then the volcanic peaks and ridges of Costa Rica, that gem of the Tropics, where security, order, and good government bless one of the richest of all the rich regions of the Caribbean. Beyond Costa Rica the broad valleys and jungle plains of Nicaragua extend to lower Honduras, then come the frowning coastal ranges of that Republic, barring the way to beautiful interior valleys, grass lands, open parks, and mountain slopes, the fairest lands about the Caribbean, perhaps the most beautiful in all the world; then the shadowy embayments of Guatemala, the sandy coast of Belize glistening before dense jungles of a rich coastal plain; then the hot, barren shores of Yucatan, with their green interiors, stretches of sand, dry table-lands, with places of verdure and tropical luxuriance in pleasing contrast; then the open waters of the dark Yucatan Channel, and then rugged shores, green hills, and cliffs of western Cuba once again, and the circuit of the Caribbean regions has been made. Truly a most attractive portion of the world, where every kind and manner of climate can be found, where every product known to the Tropics can be abundantly produced, where deep forests and unknown mountains invite exploration—lands and waters opening to a wealth incalculable, lying just at the doors of the United States.



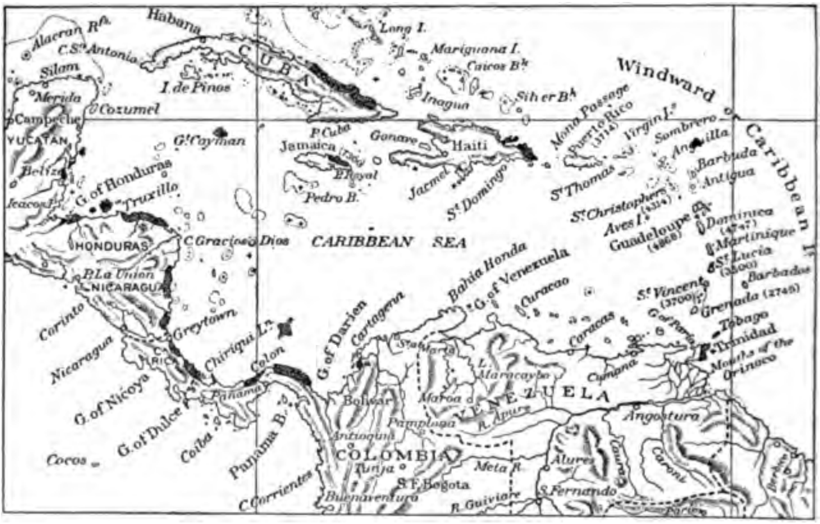
MAP 5.—Coffee regions represented by heavy shading. Coffee will grow in almost any part of the Tropics; the map indicates places where conditions are especially favorable to coffee culture.



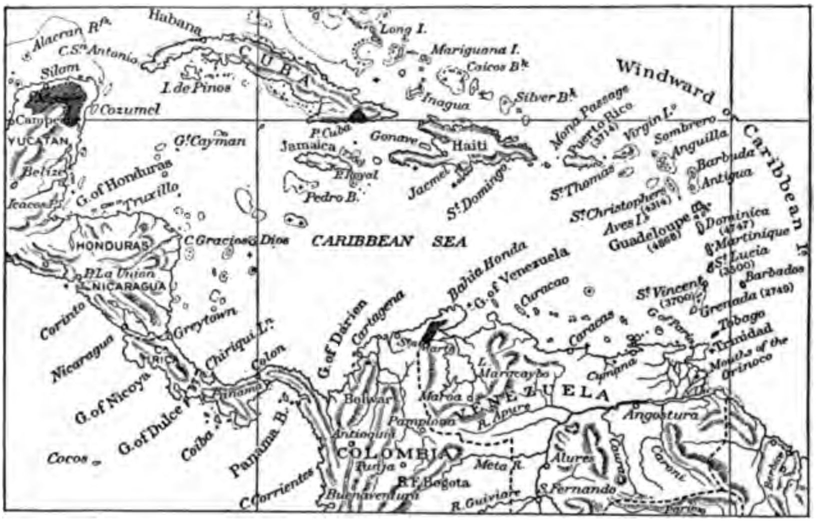
MAP 6.—Chocolate lands. Chocolate will grow in any moist locality in the Tropics. The shadings on the map indicate localities where there is depth of soil required by chocolate, as well as moisture.



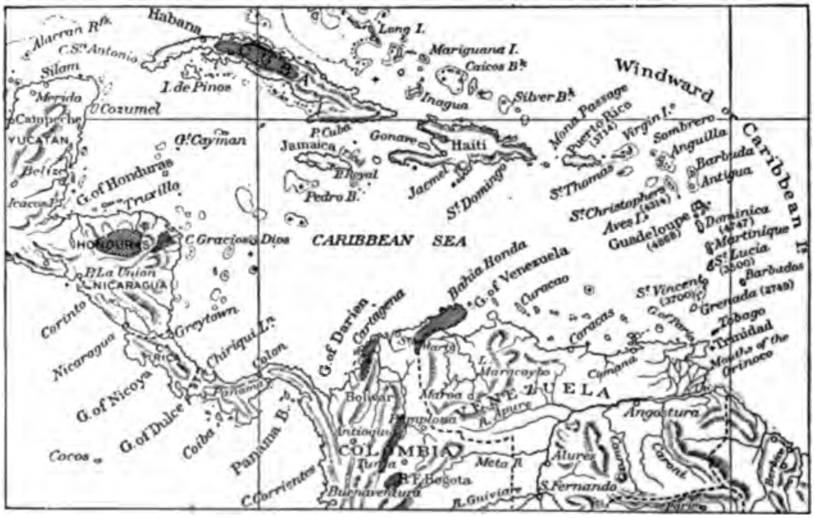
Map 7.—Bananas and other tropical fruits can be grown at the localities indicated on the map by shadings, where there is suitable soil, easy transportation to the sea, and consequently an active business.



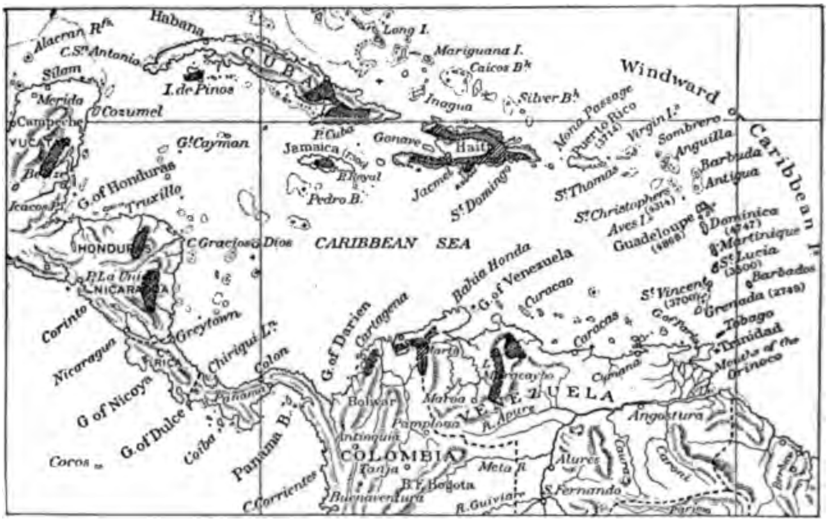
Map 8.—Cocoanut beaches are indicated by shadings on the map. Cocoanuts grow in almost all portions of the Tropics, but flourish only where there is an exposure to the trade winds, to keep away insect pests, and an easy access to the influences of the sea, which seem to strengthen the trees and sweeten the fruit. Good cocoanut lands are not plentiful and are generally pretty well occupied.



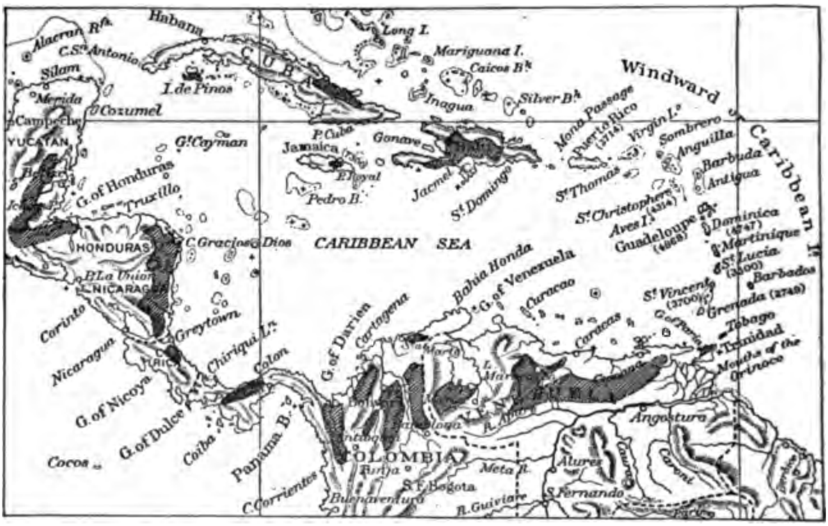
MAP 9.—Fiber-producing regions are indicated by shadings. Various plants from which fibers are obtained grow all about the Caribbean Sea, but only in certain arid regions is the growth abundant enough to provide an important article of commerce.



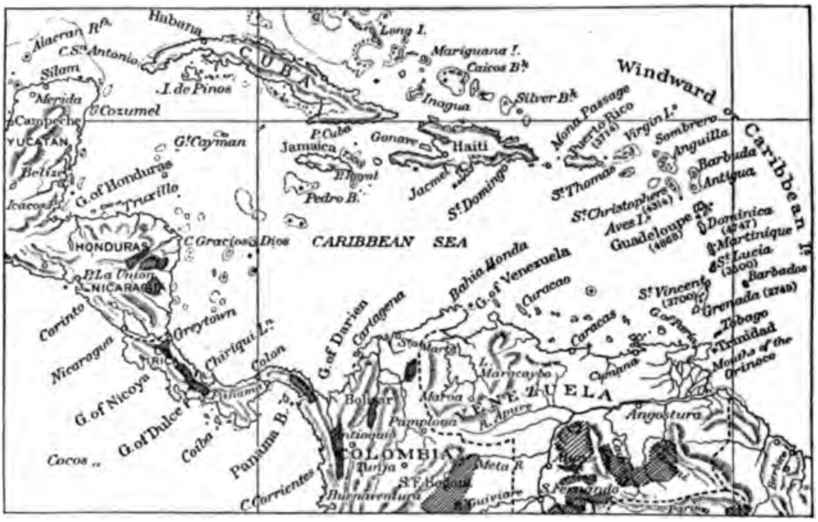
MAP 10.—Cattle regions are indicated by shadings. In all parts of the Tropics cattle raising is an important industry, but in certain localities the conditions are particularly favorable, and great herds can be pastured.



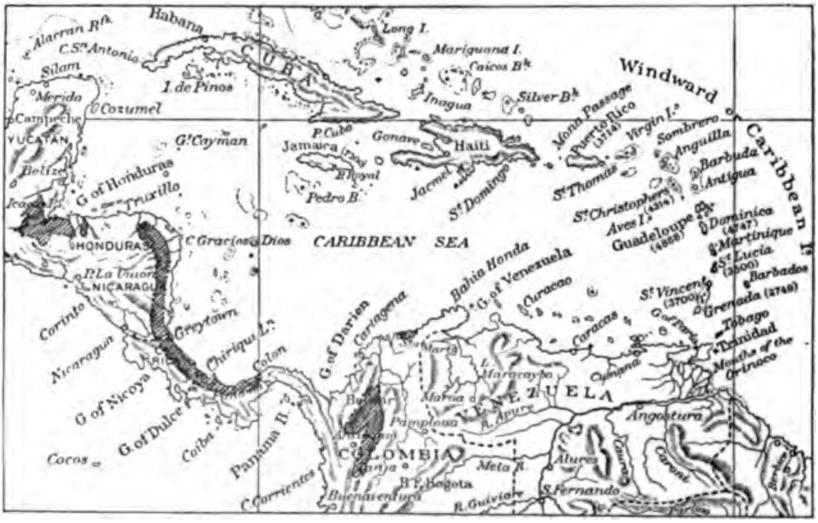
MAP 11. Hard wood can be found in any portion of the Tropics, but the finer grades are not abundant. Certain favored locations, where mahogany and other valuable woods are plentiful, are indicated by shadings on the map. In all these places, especially in Haiti and San Domingo, the wood is being rapidly cut out, and at many localities the forests are exhausted.



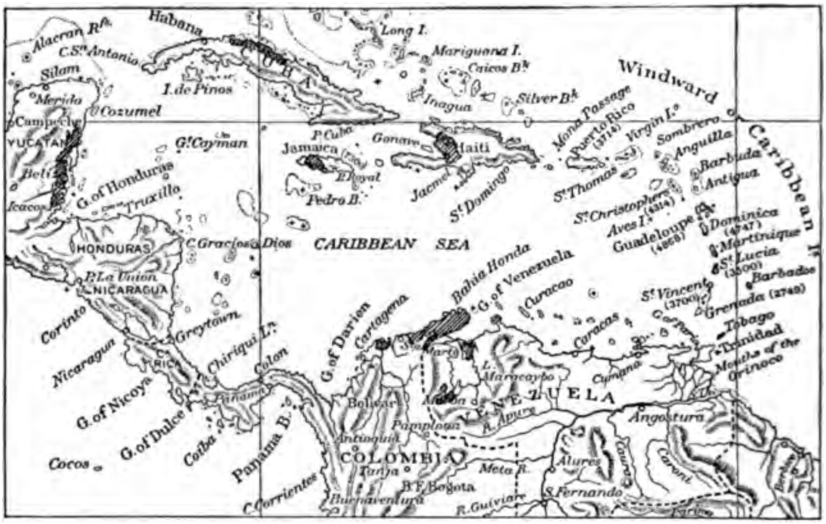
MAP 12.—Soft-wood forests. Soft woods are very abundant in the Tropics. The locations indicated are fairly accessible, and will at some future time supply abundant material for paper-pulp making.



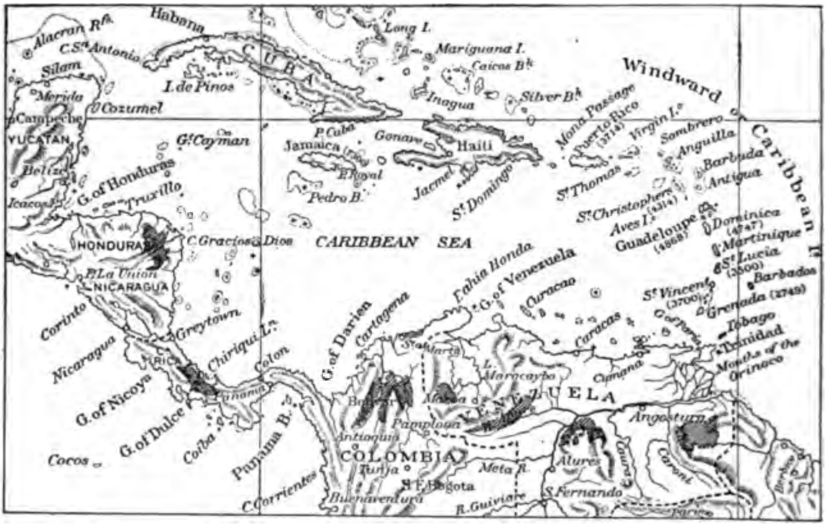
MAP 13.—Rubber forests. Rubber is being rapidly exhausted; places where it is still to be had are shaded on the map.



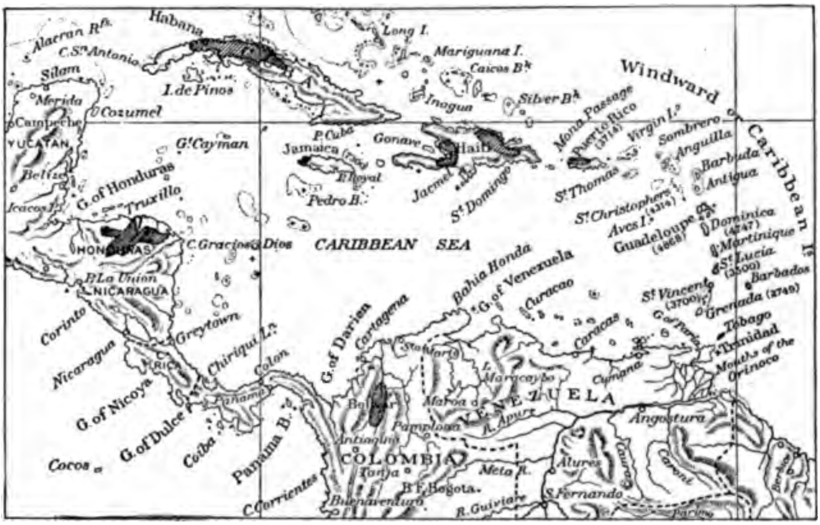
MAP 14.—Rubber forests which are generally exhausted but which could be profitably reestablished. It is probable that through the care and reestablishment of exhausted rubber forests the present supplies may be materially increased.



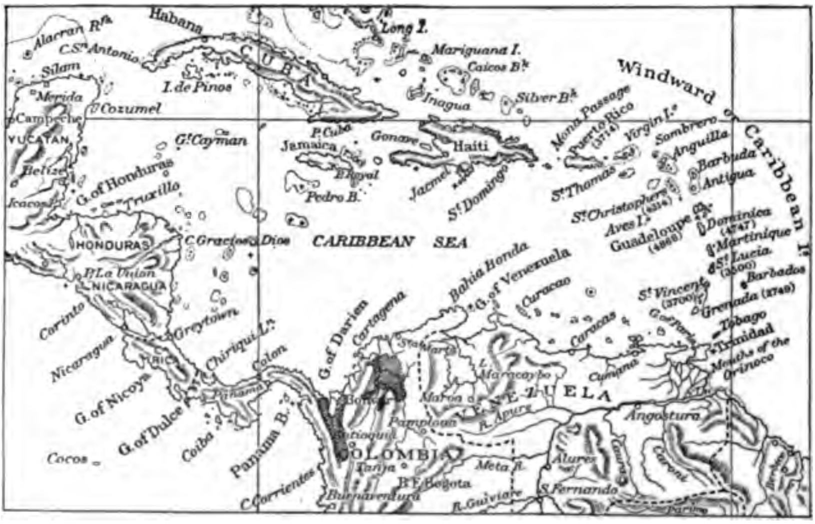
Map 15.—Dyewood and dyestuffs. These are found to some extent throughout the Tropics.



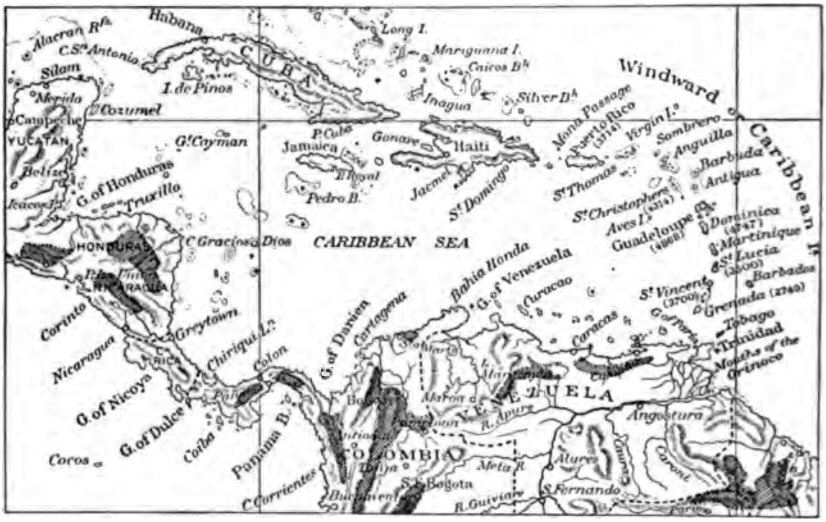
Map 16.—Palm trees are found in all moist regions of the Tropics, and nearly all bear nuts from which oil may be obtained. Regions were such nuts are especially abundant are shaded on the map.



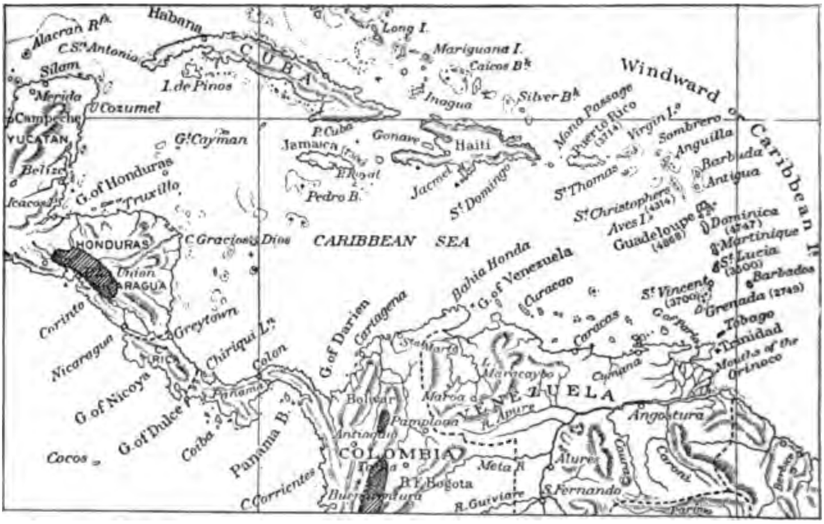
MAP 17.—Regions especially desirable for sugar planting. Sugar cane will grow at almost all places in the Caribbean regions, but at the places indicated on the map there is an abundance of product, which makes sugar planting very profitable.



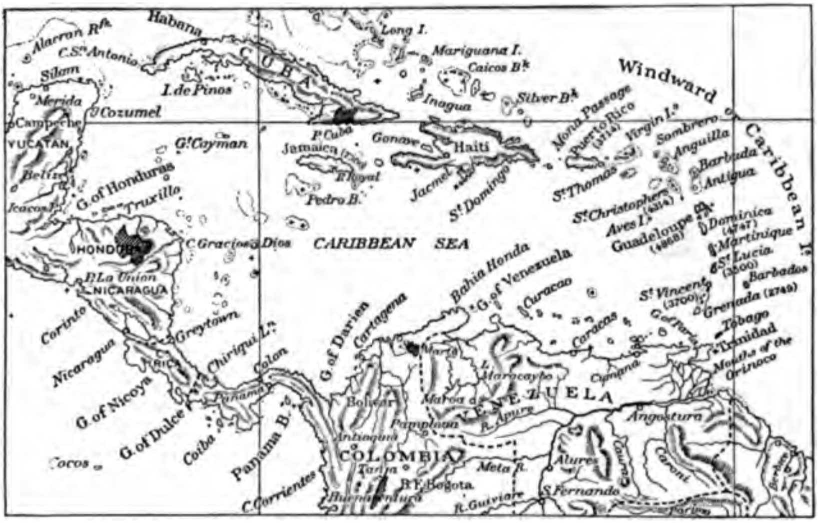
MAP 18.—Ivory nut swamps. The ivory nut is in demand, and the regions indicated are easy of access, and their yield can be materially increased.



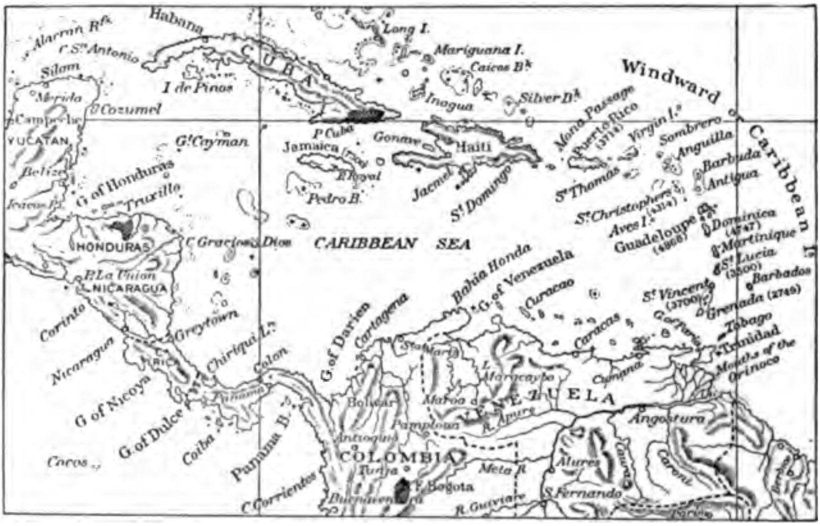
MAP 19.—Gold mines. Many regions about the Caribbean Sea are rich in gold, some of them producing the precious metal to a very considerable amount.



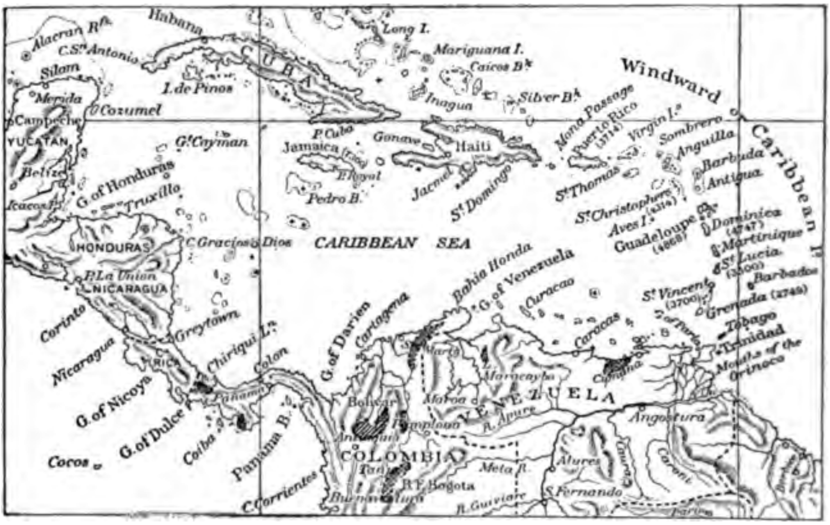
MAP 20.—Silver mines are not so abundant as gold mines about the Caribbean Sea. The principal locations are noted by shadings on the map.



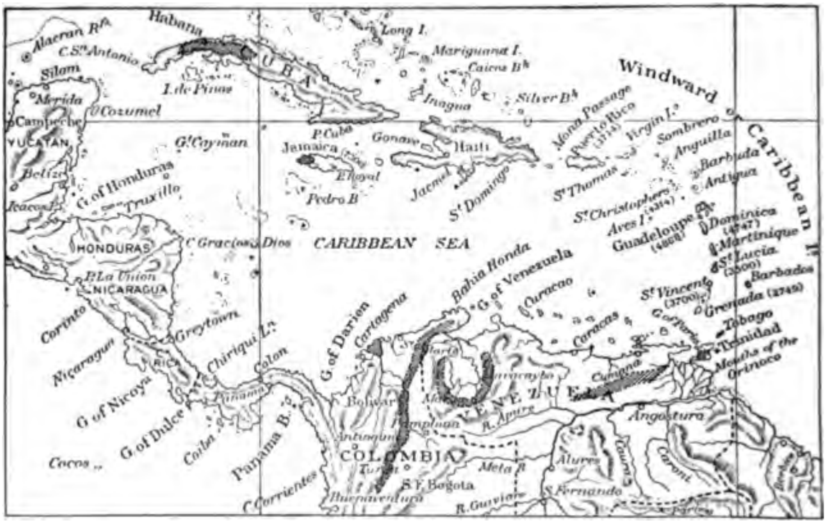
MAP 21.—Copper mines. There are several very promising copper-bearing regions about the Caribbean Sea. The most important are noted by shadings on the map.



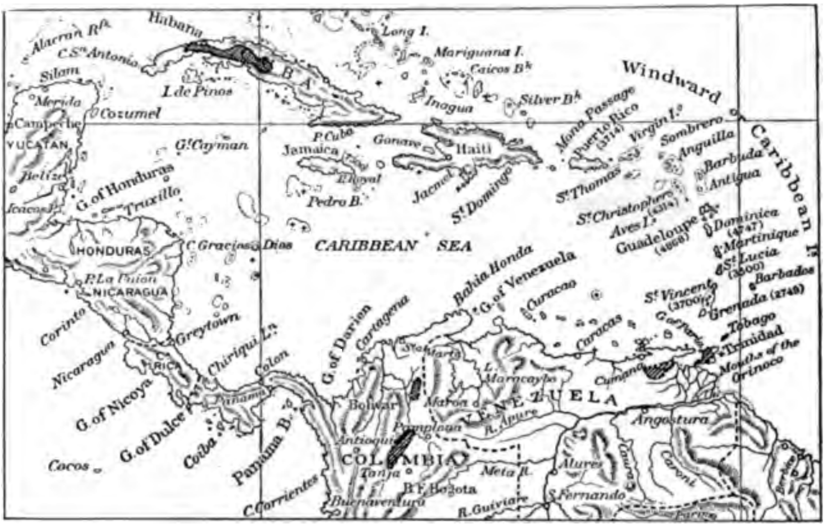
MAP 22.—Iron deposits. The Caribbean as a whole is not abundantly supplied with iron, though some large deposits are found, those of southeastern Cuba being especially notable.



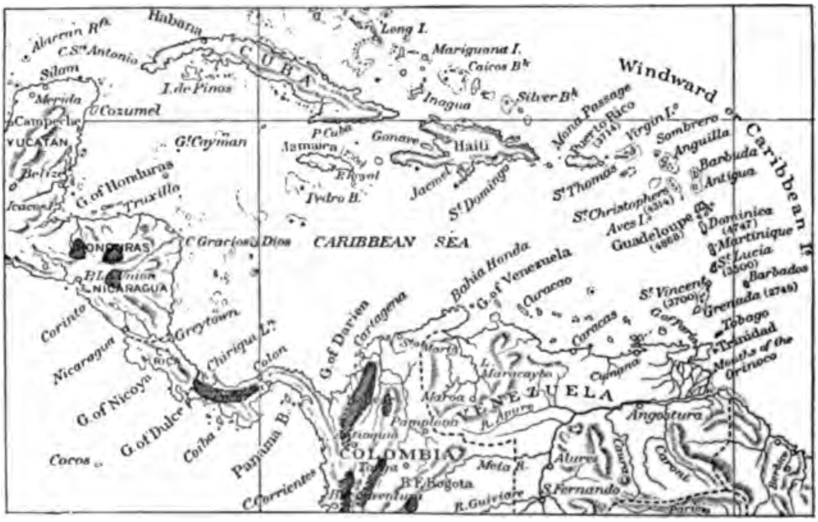
Map 23.—Coal deposits. The Caribbean regions are not well supplied with coal, and for a long time it was said that there was no coal in South America; but there are some regions which are fairly promising, and their locations are approximately indicated by shadings on the map.



Map 24.—Hydrocarbon mineral products (petroleum, natural gas, etc.). While the Caribbean regions have not been explored for these products, the geological formations indicate that some of the largest petroleum fields in the world will here be developed. Promising regions are indicated on the map by shadings.



MAP 25.—Regions where asphalt is found. One or two very large deposits are known, and there are several promising localities.



MAP 26.—Promising regions for general prospecting, where much of the mineral land is open for location by discoverers. Mining lands are abundant in Venezuela, but the insecurity of property and frequent confiscation of titles makes it an undesirable place for prospecting.

A PLEA FOR THE ESTABLISHMENT OF A COMMERCIAL GAME AND FUR PRESERVE IN THE NORTHWEST

By TOWNSEND W. THORNDIKE, M. D., Boston

South of Hudson Bay there lies a vast tract of swamp lands known in the "north country" as the "muskeg region." This term is derived from mush-keg, a swamp, a word belonging to the Cree Indian dialect.

The muskeg is characteristic of northern topography. It consists of an alluvial area of insufficient drainage, over which moss has accumulated to a considerable depth. These swamps are grown up mainly to willows and tamaracks. Scattered here and there are rocky, elevated places, or "islands," covered with a thin layer of soil, supporting a growth of black and white spruce, balsam fir, Banksian pine, aspen, canoe birch, and other trees of the temperate latitudes. But the conifers form the major portion of the forests. Because of this sylvan covering the region has been designated as the "woodlands," in contradistinction to the open prairie land, or "fertile belt," which lies farther south. Across the muskeg extend many meandering streams with deep channels and scarcely preceptible currents. In the dead-water stretches are found masses of aquatic vegetation, such as water millfoil, pond weeds, rushes, and other water plants, maintaining a luxuriant existence. Stagnant pools are numerous. Sometimes they become covered with a coat of moss of sufficient strength to sustain the weight of a man. The ground in other places is broken by mossy hummocks, the têtes des femmes of the voyageur, which make travel on foot uncertain and keep the pedestrian on the alert to avoid a fall into the surrounding mud and muck.

The banks of the larger streams support a rank growth of overhanging willows and other shrubs, while along the margins of the rivers extend an exuberant fringe of wild grasses, reeds, and rushes.

This swampy region is included, broadly, in the territories of Keewatin, Athabasca, the northern portion of Ontario, Manitoba, and Saskatchewan. This part of the Northwest is known to topographer as the Hudson Bay basin. The drainage of nearly 2,700,000 sq miles discharges into this bottom. In the earlier days the area d Ruperts Land, and was described as comprising "all of the l

whose waters flow into Hudson Bay." This great geographic depression begins on the east at the rugged Laurentian height of land, takes a general northwesterly direction, and gradually rises until it reaches the eastern incline of the western watershed which separates it from the Mackenzie River basin. The area lying between these two elevations slopes gently toward Hudson Bay, and its drainage, by means of innumerable water courses, is determined into the Arctic seas.

The bounds of the muskeg portion of this area are, broadly, on the north, Hudson Bay and the "barren grounds," beyond which lies the "north" and the "far north;" on the south, that which is referred to as the Canadian "fertile belt," which represents the northern limit of cereal-growing territory, and on the east and west, the heights of land already mentioned.

The swamp land itself begins in the historic regions of Rainy Lake and Lake of the Woods, and with a generally northwesterly trend extends in an almost unbroken line to the Athabasca and Peace rivers. Its waters empty into three great river systems—the Mackenzie, the Churchill, and the Saskatchewan—whose streams expanding and contracting form successive chains of lakes, many of which are studded with thousands of rocky islets, or dividing and subdividing into lesser streams and tributaries ramify throughout the muskeg. By means of these labyrinthine waterways, it is possible to go by canoe, during the summer, to any point in the length and breadth of the entire region without interruption other than an occasional portage.

In winter the region may be traveled on snowshoes and in dog sleds. At that time of the year the trapper is able to penetrate the woodlands, which in the summer season are almost impassable beyond a few feet from the river banks, because of the rank and exceedingly tangled growth of vegetation and the treacherous character of the land. Even if the topography permitted travel in the woodlands during the summer, the mosquitoes and the black flies in the open places would make life a burden, labor impossible, and quickly drive off the intruder. The only way to find relief is to keep in the rivers and lakes and long for night to fall, or a cool, strong breeze to rise.

Throughout the year the muskeg teems with life of many sorts. This is greatly augmented during the summer months, when the trees and shrubs are quickened with bird life.

Almost anywhere along the river banks flocks of ruffed and spruce grouse may be started, or may be heard drumming in the thickets. The majestic eagle is frequently seen hovering above, and the hawks, ospreys, the great gray owl, and his cousin, the screech owl, are common companions of the traveler, often following his canoe for many miles along the course of the stream. In the bushes and shrubs larks, ravens, kingbirds, magpies, orioles, and many other birds enliven

the scene, while blackbirds in vast numbers may be disturbed, rising as a black cloud, as the canoe is pushed through the willows and bulrushes.

As Hudson Bay is approached during the breeding season there are seen thousands of fowls—terns, ducks, geese, and the smaller species of aquatic birds, such as plovers, sandpipers, curlews, etc. These break the stillness of the swamps by their clatter when surprised or frightened at the appearance of the canoe.

Any of these may be easily killed, as wild life in these parts is not wild in the sense that the hunter or sportsman in Maine or Wisconsin understands it. Here it is possible to advance within a few feet of a covey of ducks without causing uneasiness among the birds. I have seen an Indian entice the shy and wary loon to within a few feet of him as he lay concealed on the shore. In another case a duck was induced to swim so near the boat that it might have been killed with a stroke of the paddle. Franklin speaks of an Indian who brought back to camp "a pike, a duck, and a young doe, and all he had to hunt with was a small hatchet." Once I saw an Indian kill a pike with his paddle as the fish lay basking in the sun. In none of these instances was it so much the skill of the Indian as the absence of any sense of danger on the part of the victim.

In the region farther north the swimmers and waders are more numerous, and here we may catch sight of a ptarmigan. The vegetation begins to change, showing a tendency to degenerate and become stunted. The fir trees are dwarfed and infantile in appearance. Because of this fact the region is known as "the land of the little sticks." The tree trunks and boughs are clothed with festoons of a variety of black lichen, called "caribou moss," because it is the chief article of food of the barren-ground caribou during the winter.

Still farther north the vegetation becomes more degraded. Trees become rarer and grow in widely scattered groves, and their struggle for life is precarious. In fact, vegetation could not exist were it not for the influence of the warm westerly or "chinook" winds. When these influences are lost, the arboreal growth rapidly disappears and the lower kinds of plant life, such as lichens and mosses, are substituted.

There now lies ahead of us an immense rolling, treeless waste, whose monotony is relieved only by some slough or stream, which often becomes lost in the mother earth, and after a shorter or longer subterranean passage comes again to the surface in a river or a lake. This vast tract, which stretches away to the north until its shores are washed by the Arctic waves, is justly named the "barren lands." The traveler here experiences that awful sensation of oppressive disconsolation which pervades this isolated and desolate region—the world's end.

The winter is dismal beyond expression, but with the advent of the spring everything is animation. Great bands of caribou now leave their winter stamping grounds in the woods to seek the open and bring forth their young. These bands meet other bands and form herds numbering tens of thousands. One of these hosts on its march often requires many days to ford a stream or pass a given point. In the wake of the herds follow their perennial enemies—the Dog Ribs, the Yellow Knives, and other bands of Chippewyan Indians. A relentless slaughter may take place, in which thousands of animals are killed, their skins collected and sent off to the traders, or used in making clothing, sleds, snowshoes, and a hundred and one other articles. Thousands are used simply for meat, and in many cases the tongue is the only part taken, the rest being left to go to waste or to be devoured by the wolverines. About 80,000 is the yearly number of caribou hides traded at the posts. Because of the ease with which these animals are destroyed, the Indians have the expression, "stupid as a caribou."

While caribou may be reckoned by thousands, the ducks and geese at the end of their northern migration must be computed in tens of thousands. These also are followed by their enemies, the eagles, hawks, and other birds of prey, who maintain a constant warfare on the flocks as they swim and wade hither and thither in the countless streams and marshes rearing their young. This scene of activity continues until about September. In this month the southern migration begins. The caribou enter the woods, where they separate into smaller bands and roam wherever there is food, if not killed by the hunters or the wolverines. The ducks and geese, gathering into large flocks, start on their long flight to warmer climes. At last the Barrens are barren and the terrible cold wintry silence is supreme. All is lifeless except for an occasional ptarmigan, and in the far north, the musk ox and Esquimo.

Nearly a hundred different kinds of quadrupeds are found in this region. Among these the most valuable in commerce, and hence the most vigorously pursued, are the animals belonging to the family Mustilidae. This is a large, well-defined group of carnivorous mammals bearing beautiful and durable fur. It includes the mink, wolverine, marten, skunk, badger, and otter as typical representatives. Besides these, there also are sought for their fur various species of bear, fox, beaver, muskrat, and other animals of more or less value. In no other place in the world are fur animals found in such numbers, and in no other place in the world is fur of such high average quality.

Though producing such a wonderful fauna, this immense lowland area, strange as it may seem, possesses no other natural resource of commercial value. There is, at its best, no promise in the land, and this fact is emphasized in the name of "No Man's Land," which has

Hudson Bay Company's auction sales in London for 1901, 1902, and 1903

	1903.	1902.	1901.
Badger	436	824	1,141
Bear	6,929	7,512	8,216
Beaver	34,305	49,190	45,001
Fisher	2,600	3,223	3,679
Fox:			
Silver	321	491	240
Cross	1,842	1,970	1,447
Red	3,816	6,200	5,912
White	5,586	10,717	8,487
Lynx	15,312	9,031	5,701
Marten	49,659	78,629	56,491
Mink	35,536	66,360	57,349
Musquash	924,825	1,488,287	1,650,214
Otter	5,729	10,273	8,675
Raccoon	662	1,024	1,967
Skunk	5,404	5,206	5,682
Wolf	1,933	1,790	1,347
Wolverine	625	696	635

The Hudson Bay Company's sales refer only to the number of skins traded in by this company and do not consider the returns of the numerous other traders. It is safe to say that "the company" probably handles more than half the fur taken in Canada. By doubling these figures an approximate total can be obtained.

The evidence that the game and fur animals are diminishing is abundant. More than fifty years ago a decrease was appreciated. The cause at work then is the same to-day—the utter disregard of the future, the cupidity and the selfishness of white men. The well-worn and everlasting argument that settlement is the cause is in the highest degree fallacious. On the contrary, colonization is a most potent aid in the preservation of animals, as the experience of the State of Maine attests. In this State, by means of suitable statutes, the game which was a few years ago threatened with extermination has so increased that employment is afforded to several hundred guides and hunters, and opportunities are given to many thousands of sportsmen annually. Yet throughout this State extensive lumbering, farming, and other industries are actively prosecuted. In the State of Massachusetts the last report of the game and fish commissioners was most encouraging as to the increase of deer. The fur-bearing animals are also plentiful, considering the densely populated condition of that Commonwealth. Many of these animals are regarded as vermin, and in some localities, because of their numbers, bounties have been placed upon them. A prominent wholesale fur dealer in Boston told me that he thought the Massachusetts fur was approximately worth \$50,000 to \$75,000 annually, and that it probably consisted of about 30,000 skunks, 5,000 minks, 25,000 muskrats, 2,000 foxes, and some otters.

The wanton annihilation of the buffalo was in no sense due to colonization. On the contrary the absence of colonization was the cause. Dr. F. V. Hayden, in a report to the American Geological

Survey, states "That in 1850 to 1860 250,000 buffalo were killed annually." Fifteen years later the only evidences of these wild cattle were the well-worn trails and bleached desiccated skeletons, which may still be seen. Until recently these bones were so numerous that companies were formed to gather and manufacture them into fertilizers. At this time settlement had not advanced very far.

In 1877 the Canadian government framed an ordinance for the preservation of the buffalo on its western prairies. It was done for the best interests of the Indians. The promulgation of it led almost to rebellion, and the ordinance was repealed in 1878. The region at this time had only just begun to be colonized. The same opposition would be met now in the sparsely settled parts. During my travels through northwestern Canada, whenever I mentioned that the animals should receive protection the usual reply was "Oh, there is lots of time yet." A similar remark in regard to our forests was made when the agitation for forestry supervision was begun; and yet to-day we have hardly more than thirty years' supply of timber left in the United States. The same obstruction that is encountered in the case of game laws is seen in the case of laws for the protection of trees. Incredible as it may seem, there is so much opposition that it is doubtful whether our wonderful forests of giant Sequoias in California can be saved from the ax and saw, although there are only a few hundred of them. It is not surprising that Thoreau exclaimed, "Thank God they can't cut down the clouds."

Thus we see how strong is the antagonism in a thinly settled country whenever game regulations are advanced, even though the people know that the laws are for their own profit and that the end of the animals is approaching.

We have in the United States a large area of unclaimed lands, where the bison could range as the cattle do, if they were allowed, and yet we have not a single wild specimen. That the buffalo could have been protected as are the cattle of to-day is unquestionable. In fact, they could have been utilized for the same purposes. Their meat is edible, their hide makes fine leather, and their fur would have been of great value. In time we could have had a valuable draught animal. There are buffalo farms which are endeavoring to retrieve the animal for domestic purposes, though they have not yet had very much success. It has taken ages of geological time to bring about the destruction of a species, but to-day we have seen the extermination of an animal which roamed in millions upon millions over a land which trembled beneath the tramp of their myriad hoofs.

Now, while we have the progenitors, is the time to take steps to maintain the species. The neglect of this allows our avariciousness to lead us on, and in the words of King Lear to "Kill, kill, kill," until we suddenly waken to find the forests deserted, and their former

denizens represented by a few specimens leading a precarious life in a zoological garden.

Among the larger mammals it has been found that conservation of a species requires proper, natural environment and a large number of individuals to prevent inbreeding. Up to the present time it has not been found possible to breed wild animals on a commercial scale in a healthy condition. Especially is this true of fur animals. Numerous experiments have been tried in the propagation of all kinds of wild animals, but with little or no success. The European bison, now confined to a part of Lithuania and a portion of the Caucasus, appear from recent reports to be slowly approaching extinction, in spite of all efforts to preserve the breed. The reason assigned for this is that the small size of the herd has led to inbreeding, with accompanying degeneration and slow decline. In the case of the American bison a few hundred of these animals are at present living in natural environment in the most inaccessible region of North America, i. e., the district between the Peace River and the Great Slave Lake. They are having a struggle for existence, notwithstanding the fact that they are protected, and no one hunts them. Attempts have been made to rear certain fur animals for commercial purposes, such as the skunk, mink, beaver, fox, etc. Skunks have not thrived in captivity. Minkeries have been tried in a small way, but I have not heard of their success. The Hudson Bay Company has endeavored to raise beaver on some islands in Hudson Bay, but the project is doomed because of the limitations of environment. The fox farms of Alaska, I am told, are not very successful.

The advance of civilization is not incompatible with wild life, nor does it force the animals to recede. For the cause of destruction we must go back to the period before and during colonization, when the indiscriminate use of gun and trap was customary and when there was no restraining power.

The propitious opportunity for the introduction of restraint and for the establishment of animal protection is presented during the time when the animals themselves are plentiful. To wait as we do until the stock has been destroyed to such a degree that its perpetuation is threatened is a violation of our common sense and our moral duty. This opportunity is now present in the muskeg region, and, as it is still unsettled territory, some form of repression is required for the salvation of the beasts of its woods.

That the hunting country is steadily narrowing is evident. At many of the posts the amount of fur is far from what is was, if certain animals, such as the musquash, etc., which have only recently come into demand, are excluded. The more valuable animals, such as beaver, sable, etc., are decreasing. Before the valley of the Sas-

katchewan was invaded by settlers the furs taken at a single leading post of the Hudson Bay Company would average for the year the number shown below:

Average number of furs taken annually at a single post of the Hudson Bay Company.

Bear, all varieties	400
Ermine	200
Fox:	
Blue	4
Red	91
White	400
Cross	30
Silver	3
Marten	2,000
Muskrat	200,000
Mink	8,000
Otter	500
Skunk	6
Wolf	100
Beaver	5,000
Fisher	50
Lynx	400
Wolverine	200

If this column is compared with the column which represents the returns of the entire York factory district to-day, a large falling off is seen. It must be remembered that the York factory district comprises many posts and outposts.

Returns from York factory district.

Badger	816
Bear	3,940
Beaver	17,029
Fisher	1,455
Fox:	
Silver	114
Cross	909
Red	2,743
White	2,227
Lynx	4,736
Marten	36,380
Mink	30,701
Musquash	1,285,001
Otter	4,001
Skunk	4,238
Wolf	1,489
Wolverine	424

Alexander Henry, in his journal, gives the following figures as the skin collections at Pembina, which was once an important fur section.

Skin collections at Pembina.

Skins.	1800-1801.	1802-3.	1803-4.	1805-6.	1807-8.
Beaver	1,475	1,801	1,866	1,621	[illegible]
Bear:					
Black	177	152	166	125	161
Brown	43	42	34	49	19
Grizzly	6	1	1	4	1
Wolf	194	801	360	862	68
Red fox	184	190	81	509	7
Kit	16	24	20		
Raccoon	197	127	77	152	46
Fisher	178	496	176	322	118
Otter	96	172	130	214	118
Marten	62	722	440	1,456	92
Mink	97	122	72	507	19
Wolverine	5	10	8	45	3
Loup-cervier	20				4
Moose:					
Dressed and biche	21	139	85	469	55
Shaved and parchment	92	129	288	78	167
Muskrat	27	144		12,470	
Buffalo	57	4	18	74	8
Badger	10	9	4		
Lynx		194	167		
Packs of 90 pounds each	60	94	105		60

The report from this post, though it is no longer a fur center, may be compared with returns from Rat Portage, which was formerly a principal fort in the Lake of the Woods region, but which to-day does not send out over $300 or $400 worth of peltries. Other examples could be given showing that the area of the fur country is shrinking, and that this contraction is taking place in a community which as yet is only sparsely populated and in which there is abundant space for wild animals to live were they properly protected. Even in the more remote parts of the interior it is common to travel through sections which formerly were splendid trapping grounds, but in which no animal is now seen. As the voyager paddles along through these deserted places he hears the Indians recount their adventures and their phenomenal hunts and the great number of pelts they gathered from such and such a place, now utterly destitute of fur, although the localities are as perfect breeding grounds as ever: and there is no reason why such places should not be developed into preserves for beaver and otter, and maintained and cared for by the Indians themselves, their natural guardians.

A species may be absolutely diminishing and yet the reduction not be perceptible for a long time. This is well shown in the case of the beaver. Let us consider this case. This little rodent, through whose influence it has been said the discovery and colonization of North America was promoted, was taken in such quantities in 1733 that the Hudson Bay Company exported 175,000 skins and 15,000 beaver coats (it took several skins to make one coat). In 1700 there was such an enormous number collected at Montreal that three-fourths of the collection had to be burned to make the other quarter worth exportation. In 1814 a letter written by a Northwester on the Mackenzie

River says, "The cry of 'No beaver!' is heard on the Peace River;" and David Thompson, in his journey, as early as 1794, records that the Indians complained of the killing of the beaver, and that the fur was disappearing, and yet nothing was being done to examine into the state of affairs or to afford protection. I also have heard the same complaints. To-day as one paddles along miles of streams the only evidences that attest the former presence of the once fabulous number of beaver are decayed stumps and chips and an occasional broken dam and deserted lodge. To find beaver now it is necessary to go well up on the watersheds and to the upper reaches of the Fraser and Peace rivers. Thus we see that, while we once had plenty, everything points to the ultimate destruction of this river animal, and eventually the only one left will be the one on the postage stamps of Canada or on the arms of the Dominion. But it has been questioned whether it has a right to exist even there.

All this time, although the beaver had been rapidly decreasing, the diminution was not apparent if judged from the fur sales, and the same apparent conclusion may be drawn from the present figures, for while 55,000 were killed in 1853, in 1883 the number had increased to 109,000, but fell in 1893 to 56,000; yet we have definite knowledge that the supply is decreasing. The same condition holds in the case of the martin, otter, and several other fur animals. I learn that in eastern Canada the beaver is now vigorously protected.

I have remarked that in some instances the statistics show an increase in some kinds of furs. This is because certain skins are now in demand for which formerly there was no call. One hundred years ago the muskrat was so little esteemed that the Northwest Company traded only 17,000 to 20,000 skins a year; to-day over 2,500,000 are collected. At a single post 200,000 to 300,000 may be traded in annually. In 1798 Sir Alexander Mackenzie reported that the Northwest Company sent out only 100 raccoons from the fur country. To-day the Hudson Bay Company sells on an average 500 to 2,000 a year.

From the foregoing it is evident that increase in the total output of pelts is not due to an increase in the number of animals, but is to be accounted for by a present demand for skins for which in former times there was little use.

The increasing demand of the world for fur is stimulating the prosecution of the trade, so that the annual number of pelts is kept at a high and steady mark. This is, however, entirely at the expense of the total number of animals. The consequence must be an increasing reduction of skins. This is already seen in the rarer furs, and eventually the more common varities will likewise feel the drain if some artificial protection is not afforded.

Never have there been so many traders in the field as at present and never have the more remote regions been so closely hunted. To-day there is practically only one region left in northwestern Canada which has not been despoiled of its fur. This is the country around the Great Slave Lake and the headquarters of the Liard, Hay, Peace, and Nelson rivers. It is one of the most wonderful hunting grounds in the world, and until recently was known only by report of those who had merely skirted its edges. It is a great muskeg wilderness, covered with conifer forests. In the snmmer of 1903, while I was on the Athabasca River, a Cree Indian described this area to me. He was then contemplating a hunt in it the following winter. He intended to erect his camp around the headwaters of the Nelson River. Ranging through this forest are the remnants of the American buffalo, whose numbers are estimated from a few hundred to a thousand, but the herd is probably much less than a thousand. Here roves the most gigantic moose in the world, three to four thousand of which are shot annually at the borders of the territory. Woodland caribou abound. All the species of bear are attracted especially to this region by the unlimited supply of saskatoon berries, which act as a magnet on bruin. If we approach the adjoining mountainous parts of the region the formidable grizzly may be encountered. Foxes roam in the more open areas, while in the woods, wolverines, fishers, minks, martins, and other fur-bearing animals live undisturbed. In the streams and lakes, splashing and diving, is the beautiful otter. The bird life, wondrously varied and unlimited, finds in the area supreme felicity and delight. This is probably the last untrampled "beaver country" in the world.

This muskeg region, though it is well to the west of the one I have been considering, should at once be set aside as a refuge for wild animals. At present it is isolated and difficult to reach, but homesteaders are beginning to settle the surrounding land and access to the game territory may soon be had with ease.

The opening of a new hunting ground quickly results in a rush of traders into the locality, and the building of a temporary post, which is maintained until the supply of fur begins to drop off. If the fur proves plentiful, keen competition at once springs up between the traders. So keen is this rivalry that the trapping country is being narrowed and pushed well back into the more inaccessible interior. This will continue until all regions are depleted of fur. Then the "last great fur preserve of the world," as northern Canada has been called, will be history.

That a great decrease in the animals themselves is taking place has been known for a long time, but, probably because the time has never

been ripe, nothing was done. In 1856, in a committee report[a] in regard to the Hudson Bay Company, it was admitted in testimony that there was a decrease in the animals.

A work, Notes of a Twenty-five Years' Residence in Hudson Bay, written by a member of the Hudson Bay Company, states that the animals are decreasing. The report of the Indian Department for 1898 says, "Each year demonstrates more clearly that the game and fur are steadily, if gradually, becoming scarcer. It is fortunate for the Indian that this is gradual, as it gives him time to acquire something else." In numerous conversations with the Indians I was invariably told that the game has gone in many places and that it is going in many others.

I have already remarked that fur traders as a class will not confess a diminution in fur, and that they support their statements by the statistics of fur sales, which are most misleading, if accepted without analysis. I know of nothing more difficult than to get fur information out of a trader. He closes like an oyster containing a valuable pearl at the first mention of fur. I found that the only way I could obtain any notes about the amount of fur was to work on his pride, or to arouse his jealousy and egotism by saying that some other trader, especially the Hudson Bay Company, had got many more skins than he. In one instance I found that I could approximately verify a trader's statement by estimating the cost of his trading supplies, which he had just brought in for the winter traffic. In procedure the fur trade in the interior is the exact opposite of business elsewhere. With the exception that violence is no longer indulged in, the same relations exist between the traders in the bush to-day that existed in the earlier days of strife between the X Y Z, the Northwest, and the Hudson Bay companies. The same selfish, distrustful feeling persists, and all business is done with the utmost caution and secrecy. In some instances traders pay spies to watch over the business of their rivals. The influence of the old-time methods is not entirely lost. In no other case does the worst side of

[a] Q. Has the supply of peltry at all fallen off, or has it augmented within the territories of the Hudson Bay Company?--A. The supply of peltry, since the earlier period of which I spoke to the committee, in 1803 and 1804, has diminished probably one-half, if not two-thirds.

Q. Do you mean within the territories of the Hudson Bay Company?—A. No; within all the countries to the northward of Canada, including Canada itself. All the countries easily reached have been entirely destroyed. The valuable trade of the Hudson Bay Company is in the remote districts, where, nobody having the power to interfere with them, they preserve the animals just as you do your pheasants and hares in this country. They encourage the Indians to kill only a certain number of animals when in good season for their furs, and not to kill so many as to interfere with the breed; and that is now the most profitable part of the Hudson Bay Company's trade. It comes from very remote parts.

Q. Do you mean that the decrease of one-half has been in quantity or in value?—A. In both. (Select committee report on Hudson Bay Company, 1856.)

human nature appear so quickly as in hunting for game and trading for fur. Led on by an unrestrained desire for game, the hunter or trader allows his cupidity to develop into the unchecked selfishness that dominates every phase of the fur business. This attitude is to-day both unfortunate and unnecessary, although in the early days of the Northwest it was undoubtedly the moving force in discovery and exploration.

The inhabitants of the muskeg region are a few Caucasians and Indians, the latter belonging chiefly to the Cree and Chipewyan nations. There is a very large admixture of white blood, in varying proportions, throughout the tribes, and in fact the "breeds" are in greater number than the whole-blooded Indians. They represent the controlling and responsible elements in the population, and from them are selected many of the traders, clerks, and other officers connected with the numerous trading posts in the bush. Some of the "breed" traders are able and very well to do. They would be classed as comparatively wealthy in the larger towns, where they usually reside for a part of the year. The white population is mainly Scotch, but in the western part of the territory there are some French Canadians. Both of these races have intermarried with the red man.

The Indians dwelling in this region and dependent upon it for livelihood number approximately 15,000. They either lead a nomadic life or live on reservations on the elevated and drier places scattered along the outskirts of the swamps. Their present state is pitiable. They are anything but Cooper's romantic and picturesque Indians. Nor does their life in any way resemble the misrepresentation of Indian life as portrayed at the World's Fair. Through lack of opportunity to better their condition, they have become commonplace, squalid, and dirty. This appearance is exaggerated by their "store clothes," ever tattered and torn, and by their disgusting habits. Altogether they form a repellant and saddening spectacle.

Those who reside near the fertile belt resort to farming, such as it is, but those who live in the woodlands are obliged to depend upon hunting and fishing for their support. In small areas scattered through the muskeg where there is enough soil, crops sufficient for the needs of an individual family or band are sometimes raised. In the summer some of the men find employment with the traders as able-bodied men on the York boats and bateaux, bringing in the supplies for the winter trade and taking out furs gathered in the previous season's hunt. This occupation lasts only a few weeks during the summer months. The chief sources of their maintenance are the gun and the trap, although fishing is carried on to some extent in certain places. Last year's returns from these pursuits for this swamp country was about $170,000 to $175,000. Of this amount $125,000 to $130,000 was earned by hunting.

The financial returns of this area are subject to much uncertainty, as they are affected by the abundance or the scarcity of the animals. The supply of these is influenced by many circumstances. It has been said that the ups and downs of this country are almost proportional to the height of water—high water is favorable, low water unfavorable for the trapper. In these contingencies the inhabitants have many times suffered terrible privations from lack of food and clothing, while at other times they have had plenty. Thus, last year, in the Saskatchawan district, the wet season restocked the waters and caused such an increase of muskrats as to interfere to some extent with the farming. Again, the marten may one year be very plentiful, while the following year not one is to be found. This is because periodical migrations occur in this and other species, probably due to the scarcity of rabbits, partridges, and other animals upon which they prey.

Those Indians who belong to the treaty bands receive benefits under the treaties and live on the reservations. Many of these reserves are located in regions so incapable of improvement that they hardly feel that powerful, though crude, civilizing agency, "frontier life," which includes pioneer farming, pioneer mining camps, etc. Necessarily slow, therefore, must be the assimilation and amalgamation of these Indians with civilization. That this coalescence is possible at all is due solely to the presence of the fur trade, with its pioneer influence. When this has disappeared we can truly apply to the region that terrible, forbidding phrase, "the great lone lands."

Not only does the future welfare of the Indians depend on the preservation of the fur, but also the promise of a useful purpose for the land. Of course, I expect that class of good people termed "doctrinaires," or those who think that the only way by which the Indian can triumph over the savage is to grow a crop, will disagree with me. But the profound and far-reaching influence of the fur trade in the earlier times, not only upon the destiny of the red man and the animals, but also upon the country, and even upon its history, can not be denied. The early trader brought to the Indian vices and virtues, degradation and regeneration. He became half red man, and the Indian became half white. According to the exigencies of trade rivalry, the aborigine was received with favor or with lead. This was all introductory to the condition of civilization as it is seen to-day in the fur country. Out of this developed the complex relationship of Indian and Government, now known as the "Indian question." Thus, from a simple exchange of a few pelts for some colored trifles there has gradually evolved the "reservation system," which represents a sincere desire of the red man's white brother to help him. Unfortunately, however, the system is not accomplishing its purpose. On the contrary, it is pernicious and is defeating itself. The Indian

is forced to lead a monotonous, circumscribed existence, with nothing to instill ambition into his willing mind, and has nothing to look forward to. His "learning" is just sufficient to enable him to appreciate that there is such a thing as a future and that his future is not very bright.

Is it strange that the mirthful, good-natured, jocular Indian has become a stoical, stolid, and sullen individual to those who do not know him? The sullen, impassive features are not Indian; they are the reflection of the white man. The Canadian reservation system is superior to the American. The Dominion adopted the plan of locating the Indians on many small reserves, instead of herding them on a few large tracts, and of employing men who are thoroughly familiar with Indian nature to oversee and care for them. The result has been that in Canada there has been no "Indian question," in the American acceptation of the phase. Whether the Dominion will be able to keep politics out of its future growth is a question. The advantages of the Canadian system are that the small reserves do not arrest the advance of settlement as do the larger reserves, and, consequently, the cupidity of a settler is not so much excited. Moreover, the Indians, when congregated in small numbers, cling less tenaciously to their habits, customs, and modes of thought, and are in every way more amenable to the influences of civilization. They have less opportunity for devising mischief, and lack the combination to carry it into operation. The game which contributes toward the Indian's maintenance does not disappear with such rapidity as in the presence of a large number of hunters. The Indians, if they are in farming districts, readily find a market for their produce or for their labor throughout the various settlements.

Such is the condition of the Indian in the muskeg region, and such are the influences at work against him. Unrest and unhappiness should no longer be his lot, but instead a degree of contentment and hope for the future should be given. To secure this there is only one way, and that is to preserve the fur animals from extermination. The Indian is fully alive to the fact that the animals whose pelts afford him the necessities of life and the luxuries of his part of the world—i. e., sugar, tea, tobacco—are surely doomed. In the muskeg land, after this happens—what?

What is wanted for the Indian, for the land, and for the animals is not reservation but preservation.

The influence of such an institution as an animal preserve for propagating and breeding fur and game animals for commercial purposes would do much for the Indian. It would revive his waning courage by giving him a feeling that there is a future for him. The resulting benefits of a preserve would be threefold, as the Indians, the land, and the animals would all be gainers. The same ends which

the present reservations in these regions are expected to achieve would be attained in a more practical manner. The Indian would be always occupied and self-supporting. Had America appreciated the great herds of bison and wapiti that once overran the land, located reservations near their stamping ground, and placed them under the control of their natural shepherd—the Indian—the terrible blot on the history of its dealings with the aborigines would never have become so black. The remark made by a man who ought to have known better, that "the only good Indian is a dead Indian" would never have been made.

It is somewhat surprising that the influence of wild animals should not have been considered at the time of the unfolding of the reservation system. Fur, as I have endeavored to point out, has been nearly as great a factor in the advance of civilization as the planting of cereals. In view of the fact that animal law lies at the foundation of the Indian character, permeating and controlling all his native manners, customs, and habits, a guardianship of these animals would have been a simple, natural, and yet potent adjunct to such farming as he might essay.

It is too late to think of doing this with the American Indians in America, but the time is at hand to consider the idea in connection with the rights of the Alaskan Indians. Alaska is probably one of the grandest game countries on the globe. The conditions there are ideal for the maintenance of animals, birds, and fishes. We find there the biggest bear, the biggest moose, the biggest mountain sheep, and the biggest salmon in the world.

Canada is peculiarly fitted for the establishment of a large animal preserve. Her fur industry is different from that in any other part of the world, with the probable exception of Siberia. It is a regularly organized and stable trade, and is administered as are other commercial enterprises. In the United States the volume of fur trade has perhaps not diminished much when compared with the past. It is not, however, conducted as a recognized business, but is simply followed in a desultory fashion by those who think they can make a dollar out of it. The conditions in America are such that no regular fur trade could ever be developed, and it is because of this that the animals are able to maintain their struggle for life. Northwest Canada is the natural place for a commercial animal preserve, for the higher the altitude the better is the quality of the fur. Between latitudes 35° and 60° the rare furs, such as mink, otter, marten, and ermine, are to be found in their primest grades. Tropical fur is of little use except for ornamentation, as it is extremely perishable. A great commercial preserve can be properly located only in the Temperate and sub-Frigid zones.

The advantages to the Indian of animal preserves in the muskeg

region would be not only those which are afforded by the reservations in general, but they would become as well more practical, attractive, and permanent. It is obvious that the only excuse for locating Indian reservations in this lowland country is the opportunity for hunting, trapping, and fishing. When these resources are exhausted. the only alternative for the red man will be emigration to the agricultural districts. Preserves will also afford permanent utilization of an otherwise worthless land. On many reserves the Indians are most anxious to follow hunting and trapping for a livelihood, and that they do not do so is because there is no game to secure. In those sections where it is possible to farm, the winter hunt would in no way interfere, and would be of additional benefit to the Indian.

With an intelligently organized preserve, a monopoly of the market could be had, and the price of fur could be always held up in a way similar to that in which the South African diamond mines keep up the price of their product.

That the possibility of extermination is immediate, I do not insist. Many of the fur-bearing animals do not lend themselves to extermination as easily as do game animals. But it must be remembered that man has never yet failed to annihilate a species, no matter how plentiful the supply, especially if there is a money value in the hides and pelage. The *Mustelidæ*, on account of their shyness, wariness, sagacity, and cunning are well protected, although we know that these natural attributes have not prevented several species from decreasing.

Government action on this question of a preserve should not be delayed, as emigration to the northwest Canada is rapidly going on. and the time to preserve the fur and game is before extensive colonization has taken place. This is the moment that the greatest slaughter occurs. and it is also the time when the animals are most abundant. As I have said, settlement itself is not inimical to animal life. The reason the animals are compelled to migrate in advance of settlement. is that their natural balance is disturbed, and the struggle for life becomes too fierce for them. This balance can be maintained only by proper regulations instituted in good season.

To set aside this region is simple, in view of the fact that the territory still remains in the hands of the Crown. The government has already set apart the Lake of the Woods as a fishing reserve for the sole privilege of the Indian. and there is no reason why this entire muskeg land should not also be reserved for a fur preserve.

The Indians are the most important single factor in the fur trade. as they are indirectly the producers. In view of the fact that they are practically the only inhabitants of the swamps, the creation of a commercial preserve would, after its object was understood. meet with little antagonism except from comparatively few traders. I

have talked with several of the more intelligent red men, and they seem to be much impressed. There would be many who would oppose it, as it is characteristic of the average Indian to regard only present returns as of any value. The morrow is of as little use in his mind as yesterday, but those who would not obey could be taught to do so.

The once accepted idea that government exists only for the protection of life and property is too narrow for the present day. Government now involves a conservation of forces. As society becomes more complex, it is more and more observable that "no man liveth to himself;" his life is only a part of a community and his very existence is interdependent. More and more are community interests encroaching on those of the individual. This necessitates trusteeship, and in many cases the proper trustee is the government. Especially is this the case with certain natural resources, such as forests and the game and fur animals. The government, as representing the nation, is certainly vested with authority as well as charged with the responsibility of management, and in such management it is not sufficient that the welfare of the present generation should be kept in view; regard must also be had for succeeding generations. Let us consider for a moment the game and fur animals. They are not a product of man's efforts; neither the labors nor the acts of our fathers produced them. They are the freest of nature's gifts to the community, and to allow individual expropriation of them without sufficient returns to the community is an injury to society. But the animals belong to the kingdom of nature, and by its constructive energy, reproduction and growth are constantly at work bringing forth new individuals.

That animals, as well as men, have rights, none will deny. These rights may be only vaguely defined, but they exist. One right of man is to do his duty; and one of his duties is a moral regard for the lower order of mammals, of which he himself is the primate and the predominating member. Human duty, therefore, makes it obligatory to safeguard these natural operations of reproduction from prejudicial interference, and so to insure a perpetual supply for all future time. To do this artificial protection is requisite and necessary.

The organization of the preserve must create a monopoly, else the project and its mission will fail completely. In other words, the privilege to trade fur must be entirely under the supervision of the Government. This policy of monopolization of the whole trade is not new. It has been tried under the name of "factory system,"[a] both by the Hudson Bay Company and by the United States. In the former case its success was due to the denial of the right to trade for fur to everyone except "the company." The old phrase "exclusive

[a] In describing the factory system, I have largely made use of Crittenden's History of the American Fur Trade.

privilege to trade" was one of the chartered rights of the organization. In the latter case it was a failure, although the system should have been a success. The reason it did not succeed was because the Government did not keep the field to itself, as it does the coinage of money, the transmission of mail, etc. Instead of excluding the traders it granted them license to trade, and thus degraded itself to the level of a competing trader among a horde of irresponsible and frequently lawless rivals.

The United States Congress in 1796 made an appropriation for the establishment of a "liberal trade with the Indians," and factories or trading houses were located at various points in the fur districts to exchange merchandise with the Indians at a price just above cost, the profit to be used to make the factories self-sustaining. The system lasted until 1822 and was then abandoned. The private practices of the traders were not such as the Government could afford to tolerate in its agents. The Government was handicapped because it could not sell whisky or give credit, and because it had to use inferior articles in trade in order to patronize home industries. The agent was often a salaried political employee and stranger to the Indian and his ways. The traders, on the other hand, were not embarrassed by any of these drawbacks. They, moreover, often followed the Indians in their hunts, knew them and their habits, and not infrequently married among them. Under these circumstances the only possible result was failure. Thus was doomed a system fraught with possibilities of great good to the Indian, a system which, if followed out as it should have been, would have led the Indian to his new destiny, saved the animals, and averted the long and bloody wars interwoven with corruption and bad faith, and the pages of American history would not have been stained with that chapter whose now familiar title is "A Century of Dishonor."

If the Government should to-day establish a commercial animal preserve on the factory system none of these obstacles would embarrass the action or its execution. The outcry of the traders could be satisfied by suitable compensation as in other cases in which the Government sets aside land, i. e., forestry reservations, parks, and game preserves, etc.

With the establishment of a preserve in which hunting is to be a permanent occupation, the education of the Indian or future hunter should be conducted along definite lines. An Indian whose future is that of a hunter should be taught the value and the objects of the preserve. He should also understand that he is being fitted for the purpose of developing it in its numerous directions to the highest point. He should also know that not only are he and the fur concerned in the object but also the land and its usefulness. During the warmer months, when hunting and trapping are not followed, he should be

required to work on the boats, etc., preparatory to the winter traffic, or, where possible, to fish or farm. Efforts should be directed toward the prevention of indolence which so easily overtakes one in the fur country during the summer time. For this reason the apostolic doctrine that if a man will not work he shall not eat should be inculcated thoroughly into the mind of a hunter. In the case of an Indian who is to dwell in this preserve, it would be ridiculous to teach him typesetting and similar trades useless in the bush. What such an Indian needs is instruction in the practical affairs of life; knowledge to fit him for meeting the conditions in the land where he is to live; and those things that he himself must of necessity do in the future. In other words, he should be taught usefulness in his home life. Paradoxical as it may seem, an Indian is much less skillful in the art of hunting than the white man, and much may be taught him about trapping, shooting, and the animals in general.

I believe a preserve would prove so attractive to the Indian mind that Indian immigration would arise, as life in the woods is and always will be more acceptable to their constitutional bent than tillage of the soil.

Life on a preserve would have all the advantages of the reservation and few of its defects. Through the aid of the numerous missions already established in the region the acquisition of the habits, methods, and pursuits of civilization, which has been going on since the region was discovered, even during the time when there was no reservation system, will continue. The influence of these will be more marked on Indians who know that the land holds a future for them, and contentment, enterprise, and self-reliance would follow in their case as it would not in the case of those who feel that everything is uncertain and that there is no hope. That the Indian is keenly impressed with this feeling is apparent to one talking with him. Why should he not be, since he is but little different from his neighboring white brother, and as fully capable of high development as the Caucasian? The Indian is worth saving, the animal is worth saving, the land is worth saving—let them be preserved.

LA VALEUR COMMERCIALE ET INDUSTRIELLE DU SAHARA FRANÇAIS.

Par. E. F. GAUTIER, Chargé de Cours à l'École Supérieure des Lettres, Alger, Algérie

Dans les trois dernières années le Sahara français, de fermé qu'il était, s'est ouvert à l'investigation géographique. Les causes de cette révolution ont été exposées ailleurs. A l'heure actuelle elle n'a pas eu encore toute la portée qu'on est en droit d'en attendre; la plus grande partie de cet immense domaine reste encore inconnue; mais du moins nous avons acquis nombre d'idées nouvelles sur sa partie nord, une large bande au sud de l'Algérie, la région des oasis sahariennes et le pays des Touareg. Cet accroissement de nos connaissances a précisé nos notions sur la valeur commerciale et industrielle de cette possession dont la production économique fait un contraste si fâcheux avec la superficie.

VALEUR AGRICOLE

Assurément on n'a jamais pu se faire d'illusions sérieuses sur la valeur agricole d'un désert. Pourtant ce désert nourrit une population si faible soit-elle. Il a ses cultivateurs, fixés dans des oasis et des nomades, qui paissent leurs chameaux dans les hautes vallées. Sur l'importance numérique des uns et des autres les derniers renseignements établissent qu'on avait fait des évaluations exagérés.

Le complexe d'oasis auquel on applique communément l'appellation de Touât et qui se subdivisent effectivement en Touât, Gourara et Tidikelt, n'a pas plus de 1,500,000 palmiers, qui nourrissent maigrement une population de 50,000 habitants. Pour être complet il faut ajouter les oasis de l'ouest Saoura et de l'ouest Zousfana (Beni-Abbes, Igli, Tar'it) avec une dizaine de mille âmes, soit environ un chiffre total de 60,000 habitants échelonnés sur une ligne sinueuse d'oasis dont la longueur totale excède 600 kilomètres. On avait espéré mieux, ce chiffre, fourni par un recensement administratif, est inférieur de plus de moitié aux évaluations antérieures. (Voir par exemple celles de Deporter).

Sur la population des hautes vallées Touareg nous n'avons pas encore de renseignements aussi précis. Il n'a pas été fait de recensement.

tégée par une carapace épaisse et dure de grès quartziteux dévoniens, et l'on s'explique sans peine que cet obstacle ait arrêté les Touareg; aux oasis le travail des foggara et des puits a trouvé des conditions autrement favorables dans les terrains meubles ou semi-meubles du quaternaire et du crétacé inférieur. Il est clair cependant que notre outillage moderne aura facilement raison des grès dévoniens. On peut s'attendre à la création d'oasis nouvelles sur tel ou tel point qu'on pourrait dès à présent désigner du Mouidir, par exemple. Ce ne sera pas assurément un événement d'importance mondiale, le désert ne deviendra pas notablement plus apte à payer ses frais d'occupation, mais ça aura été une besogne humanitaire et de conséquence heureuse pour la police du Sahara: dans un pays où le banditisme est conditionné par la famine chronique, une équipe de puisatiers rend apparemment plus de services qu'un piquet de gendarmerie.

RICHESSES MINÉRALES

C'est sur les richesses minérales du Sahara, naturellement, et non pas sur ses produits agricoles qu'on a pu fonder quelqu'espoir. Il est invraisemblable assurément qu'un secteur aussi étendu de la surface terrestre en soit complètement dépourvu: mais quels énormes gisements faudra-t-il et dans quelles conditions minéralogiques favorables pour que l'exploitation demeure possible malgré la distance et le manque d'eau. La partie du désert la moins inconnue, et sur laquelle il est possible de risquer dès à présent quelques pronostics précis, est du moins la plus proche de l'Algérie et la plus abordable; une ligne de chemin de fer en voie de progression entame sa lisière et attend du fret; c'est la ligne de Saïda, Aïn-Sefra à Beni-Ounif, qui atteindra bientôt Ben-Zireg.

Dans cette région sud-algérienne les explorations de M. G. B. M. Flamand, il y a quelques années, ont attiré l'attention sur la présence de nitrates. Aussi longtemps que nos renseignements sur les nitrières du Gourara sont restés vagues on a pu leur prêter quelque ressemblance avec les fameuses "caliches" du Pérou. Mais cette hypothèse est loin d'avoir été confirmée par la réalité. Les nitrières se trouvent dans trois etites oasis sur la frontière du Gourara et du Touât (Ouled-Mahmoud, a, Tililan). Elles n'ont pas été, à vrai dire, sérieusement étudiées u'on n'a fait aucune recherche en profondeur, mais il est certain urface les affleurements sont insignifiants. Ce sont de petites centaine de mètres de diamètre, où la terre salpêtrée 6 à 7 pour cent de nitrates. Ces cuvettes sont es secondaires (argiles albiennes), et il semble être encore qu'il faudrait des fouilles point. Les nitrières se trouvent anciennement habités; et jusqu'à érer comme de vieux dépotoires.

mentaire du désert. L'agriculture d'oasis est, il est vrai, bien loin d'être rudimentaire, elle est au contraire très évoluée, intensive. Le système des "foggara" a été poussé, à travers les siècles, au voisinage de la perfection; c'est, on ne l'ignore pas, un système de drainage et de canalisation souterraine; au voisinage de chaque oasis le sol est miné de conduits d'eau sur des centaines de kilomètres carrés; il y a là une accumulation séculaire de travail et d'ingéniosité qui inspire le respect et fait paraître utopique tout projet d'amélioration. Mais si on ne peut guère améliorer le système, il ne serait pas impossible d'en imaginer un meilleur.

Le gros inconvénient de ces centaines de kilomètres de canalisations, creusées à plusieurs dizaines de mètres de profondeur, dans un sol meuble et friable, c'est la difficulté de leur entretien qui soustrait annuellement à la culture un nombre considérable de bras. L'eau d'irrigation aux oasis est loin d'être utilisée intégralement faute d'un nombre suffisant de cultivateurs; il n'est pas possible d'autre part de compter sur l'accroissement normal de la population, qui devrait être conditionné au préalable par une augmentation des moyens de subsistance: c'est un cercle vicieux. On peut en sortir en rendant à l'agriculture proprement dite les bras qu'immobilise actuellement l'entretien des canaux d'irrigation. Ce résultat serait atteint par le forage de puits artésiens, qui donneraient une eau immédiatement utilisable, vendue à pied d'œuvre.

On sait du reste que les indigénes sahariens connaissent les puits artésiens depuis une antiquité reculée; ils en attribuent la paternité à Bou Cornéïn "le cornu," un personnage mythique, aux trois-quarts oublié par la Berbérie islamique mais qui fut certainement le dieu égyptien Ammon, et dont les représentations en gravures tapestres, sous la figure d'un bélier casqué d'un disque solaire, abondent dans l'Atlas saharien. Dans les oasis de l'ouest R'ir d'Ouargla et même dans deux oasis du Gourara, le forage et l'entretien des puits artésiens sont confiés à une corporation spéciale, celle des "retass." Mais des expériences multiples, qui ont revivifié l'ouest R'ir et l'Ouargla ont établi l'immense supériorité du puisatier européen sur le "retass." La présence d'une nappe artésienne au Gourara-Touât-Tidikelt n'est d'autre part pas douteuse, puisqu'il y existe déjà de rares puits indigènes fort anciens, et quelques puits européens récents (El Goléa-In Salah). Le mouvement commencé ne s'arrêtera pas, et il est permis d'en augurer quelques résultats heureux.

Mais c'est surtout en pays Touary que nos puisatiers semblent appelés à faire œuvre utile. Les Touareg ne semblent pas condamnés par une nécessité géographique immuable à rester un peuple exclusivement pasteur. Quand on parcourt le Mouidir et l'Ahnet on y rencontre des sources, dont quelques-unes sont chaudes, il faut donc admettre la présence d'une nappe d'eau dans le sous-sol, elle est pro-

tégée par une carapace épaisse et dure de grès quartziteux dévoniens, et l'on s'explique sans peine que cet obstacle ait arrêté les Touareg; aux oasis le travail des foggara et des puits a trouvé des conditions autrement favorables dans les terrains meubles ou semi-meubles du quaternaire et du crétacé inférieur. Il est clair cependant que notre outillage moderne aura facilement raison des grès dévoniens. On peut s'attendre à la création d'oasis nouvelles sur tel ou tel point qu'on pourrait dès à présent désigner du Mouidir, par exemple. Ce ne sera pas assurément un événement d'importance mondiale, le désert ne deviendra pas notablement plus apte à payer ses frais d'occupation, mais ça aura été une besogne humanitaire et de conséquence heureuse pour la police du Sahara; dans un pays où le banditisme est conditionné par la famine chronique, une équipe de puisatiers rend apparemment plus de services qu'un piquet de gendarmerie.

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De semblables nitrières minuscules, en relation avec d'anciennes habitations humaines, existaient en Algérie sur un grand nombre de points au moment de la conquête. Là comme ici elles étaient exploitées par les indigènes pour la fabrication de la poudre; la concurrence écrasante des poudres européennes a tué depuis longtemps en Algérie cette petite industrie locale, qui ne se maintiendra pas davantage au Gourara.

Les sahariens connaissent et exploitent d'autres produits minéraux; au sud du Tidikelt des gisements d'alun et d'autres de sulfate de fer (en arabe "tomela"), qui semblent en relation avec des schistes argileux carbonifériens, sont utilisés par les Touareg pour la coloration de leurs cuirs. Le fait n'est pas sans intérêt pour l'étude de la civilisation touaregue, mais il n'y a pas apparence que l'alun et le sulfate de fer contribuent jamais à la prospérité économique du désert.

Beaucoup plus intéressantes sont assurément les mines de cuivre et de plomb exploitées par les indigènes, elles sont assez nombreuses et leur existence était encore insoupçonnée il y a quelques mois. Il faut se garder naturellement de donner au mot "exploitation" son sens européen. Tous les indigènes sont familiers avec l'aspect et la nature de la galène, et ils en ont noté les gisements exacts; au fur et à mesure de leurs besoins ils vont y chercher le minerai nécessaire à la fonte des balles; les femmes emploient aussi la galène, écrasée et réduite en poudre, pour se noircir le tour des yeux; c'est le fameux "Koheul," qui est presque toujours à base de plomb, quoique le sens littéral du mot soit antimoine.

Le minerai de cuivre est d'un usage bien moins courant, entouré de plus de mystère; il n'intéresse pas directement la grande masse de la population qui n'en a pas l'emploi, mais seulement les orfèvres juifs, qui l'utilisent en petites quantités à des alliages inavoués et fructueux. Les juifs fabriquent dans le sud de la Berbérie et aux oasis des bijoux d'or et d'argent d'un travail barbare et original, dans lesquels l'or et l'argent n'entrent que pour une part. Les bijoux d'or en particulier, fabriqués, disent leurs vendeurs, avec "l'or du Soudan" se recouvrent vite d'une couche de vert de gris qui ne laisse pas le moindre doute sur la véritable nature de l'or soudanais. A quel point la clientèle indigène est sans défense contre cette supercherie, c'est ce que montre l'appellation donnée couramment, en toute candeur et sans nulle ironie, aux mines de cuivre: les indigènes les considèrent comme des mines d'or et d'argent.

Il va sans dire que des mines ainsi exploitées n'ont pas de galeries bien longues, ni un personnel de mineurs bien sérieux. Des galeries existent pourtant sur certains points, et il n'est pas douteux que les marocains du sud aient par atavisme et évolution un tempérament de mineurs. Aux mines de fer de Beni-Saf, dans la province d'Oran,

on a dû renoncer aux ouvriers marocains du Rif, qui sont pourtant les proches voisins de la mine, mais qui ont montré au travail des galeries une inaptitude de paysans. Beni-Saf recrute son personnel indigène parmi les gens du Sous et du Sahara marocain; c'est-à-dire que la suggestion de l'embauchage s'exerce efficacement à plus d'un millier de kilomètres. Parmi les nombreux émigrants marocains qui passent annuellement la frontière algérienne, il est curieux que tous les autres se consacrent aux travaux agricoles, et ceux-ci seulement, les sahariens, au travail des mines, et cela non seulement avec prédilection, mais encore avec une sorte de compétence.

On ne sait rien encore de précis sur ces gisements, sauf pourtant leur existence et leur nom. Il faudra du temps et des prospections sérieuses pour être fixé sur leur valeur marchande. Il reste acquis cependant que ce coin de Sahara desservi par le chemin de fer de Beni-Ounif est mineralisé.

On distingue aisément deux catégories de gisements. Les plus nombreux et les mieux connus sont à la lisière du Sahara, sur le versant sud de l'atlas, aux sources de la Zousfana et du Guir, dans le Djébel Grouz, etc. Cette partie de l'Atlas diffère notablement de celle qui lui fait suite à l'est, et qui est anciennement connue. En Algérie l'Atlas d'Aïn-Sefra est presque tout entier gréseux, et c'est d'ailleurs une région de plis ébauchés. Au delà de la frontière, au voisinage de Figuig, les plissements sont énergiques, l'Atlas se termine au sud par un pli renversé au contact de vieux bancs de sable primaires (Djébel Bechar, Djébel Antar). En même temps les grès crétacés disparaissent, et presque toute la masse du Grouz est constituée par des calcaires jurassiques; ce sont ces calcaires plissés et fissurés qui contiennent des filons métalliques. Entre les sources de la Zousfana et celles du Guir (environ 150 kilomètres), on connaît jusqu'à sept affleurements, d'importance inégale, exploités plus ou moins par les indigènes.

D'autre part, outre ces gîtes métallifères des calcaires jurassiques, il faut admettre l'existence d'une catégorie tout à fait différente de gisements. On signale en effet une mine indigène importante (pour le pays s'entend) beaucoup plus au sud, sur la rive droite de l'ouest Saoura dans une région incontestablement primaire et tout à fait en dehors des plissements de l'Atlas. Il n'y a pas lieu de mettre en doute sa réalité, on en a des échantillons recueillis par un européen;[a] et quoique les conditions géologiques de ce gisement soient encore inconnues, on ne peut guère se soustraire à la conclusion que les terrains primaires sont également minéralisés.

Les gîtes métallifères du Sahara sud-oranais nous apparaissent donc

[a] Le lieutenant Rousseau.

actuellement comme la moins illusoire des espérances que le Sahara a fait naître, sinon encore tout à fait comme une réalité palpable.

Dans la liste de ces espérances on ne peut pas oublier la houille. Sa présence n'a jamais été signalée, mais les dernières explorations ont montré l'énorme extension du calcaire carbonifèrien; une bande puissante de cet étage coupe en écharpe tout le Sahara sud-algérien, depuis le Djébel Bechar jusqu'aux premières pentes du Mouidir; elle se prolonge d'ailleurs fort au-delà de ces limites à l'est et à l'ouest. Foureau l'a reconnue au plateau d'Eguélé et Lenz, dans l'extrême ouest du Sahara. Qu'une bande aussi étendue de carbonifèrien ne soit associée nulle part à peu ou prou de houille, c'est ce qu'on ne peut admettre avant de l'avoir constaté expérimentalement. Cette constatation loin d'avoir été faite n'a même pas été tentée; elle sera d'ailleurs malaisée; tandis que le contact inférieur, avec le dévonien, est facilement observable, le contact supérieur au contraire, le seul qui importe dans l'espèce, est presque partout masqué par des terrains plus récents. La bande carbonifèrienne fait d'ailleurs partie, c'est encore un résultat des explorations récentes, d'un complexe très curieux de vieux plissements primaires arasés, qui couvre une partie considérable du désert et qui se continue, à travers l'extrême ouest marocain, par la meseta espagnole et la chaîne hercynienne de l'Europe occidentale. Et, si l'on se souvient que presque tous les gisements houillers européens sont associés à la chaîne hercynienne, c'est une raison de plus pour n'admettre que sous bénéfice d'inventaire l'absence de la houille au Sahara. Il faut attendre les résultats d'une prospection qui exigera beaucoup de temps pour être complète.

Il est clair d'ailleurs que des gisements houillers, s'il s'en trouvait, seraient affectés du même coefficient négatif formidable que tant d'autres richesses minérales éventuelles; par le seul fait qu'elles seraient au Sahara si loin de la côte et dans un pays dépourvu de vie. La houille du Sahara n'aurait aucune chance de venir faire concurrence à la houille anglaise dans les ports de l'Algérie. Elle remédierait pourtant à l'absence de tout combustible minéral dans l'Afrique du nord, elle rendrait des services locaux; les gîtes métallifères, par exemple, deviendraient tout particulièrement intéressants s'il se trouvait à proximité du combustible nécessaire à leur exploitation.

LE COMMERCE

C'est tout particulièrement en matière de commerce que le mirage saharien a été décevant. Certes, on ne s'est jamais imaginé qu'il pût être question sérieusement au désert d'exportation et d'importation, en échange des quelques produits alimentaires, textiles ou industriels dont ils ont besoin, ces rares habitants n'ont à offrir qu'un peu de sel, des dattes et quelques plumes d'autruche. Mais ça été une

illusion persistante que de croire à l'importance du Sahara comme pays de transit; il est vrai qu'il sépare deux pays très différents, le Soudan des noirs et l'Afrique tropicale d'une part, les pays méditerranéens de l'autre. Entre ces deux mondes si contrastés l'esprit imagine d'innombrables possibilités d'échanges, et on s'est longtemps mépris sur l'importance commerciale des caravanes, entrevues à travers les récits des indigènes et les souvenirs des mille et une nuits. De là le projet de chemin de fer transsaharien qui a longtemps hanté beaucoup de bons esprits en France. Le malheureux Colonel Flatters avait fait de l'étude de ce projet un des principaux objectifs de son voyage. Au contact de la réalité toutes les illusions se sont dissipées à tout le moins sur l'intérêt économique du transsaharien; on n'imagine plus qu'il puisse payer ses frais. A part un peu de poudre d'or et quelques broutilles, on ne peut plus se dissimuler que le principal aliment du commerce transsaharien a été et reste encore (au Maroc et en Tripolitaine) l'esclave nègre, et on n'imagine pas le chemin de fer véhiculant une marchandise de ce genre. D'ailleurs où aboutirait-il? Est-ce à Tombouctou? Mais depuis que la paix française règne au Sénégal et au Soudan, Tombouctou a toutes ses communications à l'ouest avec Saint-Louis, communications faciles, par voie d'eau sur une grande partie du parcours; le transsaharien ne pourra jamais faire concurrence à la voie du Niger et du Sénégal. Est-ce, au contraire, au lac Tchad qu'il aboutirait? Mais les grands empires soudanais ont beaucoup perdu du prestige que les descriptions de Barth leur avaient valu.

Les derniers explorateurs, capitaines Lenfant et Chevalier, nous dépeignent le lac Tchad comme un chott en voie d'assèchement, et nous recommandent d'y avoir pour préoccupation principale la réduction de nos frais d'occupation. Le pays fertile, susceptible de payer, ne commence qu'assez loin au sud du Tchad, dans une zone dont l'Oubangui et le Congo sont les voies naturelles de communication.

Si le chemin de fer semble mort-né, en revanche le télégraphe transsaharien pourrait bien être viable. On l'imagine très bien faisant victorieusement concurrence aux câbles sous-marins qui relient le Sénégal à la France. Il aurait d'abord sur eux, au point de vue politique et militaire, une supériorité évidente, celle de la sécurité de transmission. D'ailleurs le Sénégal et le Soudan français font en ce moment de grands efforts pour compléter leur outillage économique; si une ère de prospérité s'ouvrait pour ce vaste pays, il n'y a pas de raison pour que le télégraphe transsaharien ne devienne une entreprise suffisamment rémunératrice. Si en matière de transport la voie d'eau a une supériorité décidée, il n'en est plus de même en matière de télégraphe. On peut dire d'ailleurs que cette ligne télégraphique est en voie de construction, non pas qu'elle ait été arrêtée en principe, mais elle se pro-

longe annuellement par tronçons, par nécessités successives et décisions de détail; d'un côté, elle est parvenue à Tombouctou, et de l'autre à Tar'it; il y a apparence que ses deux extrémités, l'algérienne et la soudanaise, se rapprocheront progressivement jusqu'à se rejoindre.

En résumé, une étude sur la valeur commerciale et industrielle du Sahara français conduit nécessairement à des conclusions négatives. Tout au plus y a-t-il lieu de signaler, dans une région restreinte sur la lisière septentrional, quelques espérances d'un développement minier. Le grand fait nouveau c'est qu'il devient possible d'inventorier cette portion considérable de la calotte terrestre. Mais cet inventoire sera vraisemblablement plus profitable à la science du globe qu'à l'industrie et au commerce.

L'ESSOR DES ÉTATS-UNIS JUGÉ DU VIEUX CONTINENT

By Prof. G. BLONDEL, Paris, France

L'un des faits qui, pendant les dernières années du dix-neuvième siècle, a le plus vivement frappé les nations de la vieille Europe c'est assurément le prodigieux développement des Etats-Unis. L'essor économique de la grande République Américaine a déjà provoqué de nombreuses communications au sein de toutes les sociétés géographiques, de toutes celles au moins qui, comme la Société de géographie commerciale de Paris, dont j'ai l'honneur d'être en ce moment le délégué, étudient d'une façon spéciale la manière dont l'humanité travaille à mettre en valeur cette terre nourricière, sur laquelle se déroule son existence et dont elle est encore loin d'avoir utilisé toutes les ressources, exploité tous les trésors.

Je ne puis donner ici qu'un aperçu des sentiments que le spectacle du développement des Etats-Unis a fait naître chez les peuples européens. Ces sentiments, on peut les ramener à trois principaux: un sentiment d'admiration, un sentiment de crainte, et enfin le désir de critiquer certains côtés, et même des plus brillants, de la civilisation américaine.

I. D'abord un sentiment très sincère d'admiration. On trouverait, je crois, peu d'Européens qui ne rendent hommage à cette énergie, à cette force de volonté qui vous donnent, Messieurs, une si grande confiance en vous-mêmes, et qui se traduisent par une ardeur au travail, un esprit d'initiative qui frappent au plus haut point ceux qui viennent étudier votre civilisation. L'énergie qui vous anime a engendré à son tour un optimisme qui a donné des résultats d'autant meilleurs qu'il se double d'une remarquable persévérance. Vous ne paraissez pas connaître ce sentiment si répandu dans la vieille Europe, le découragement; et on rencontre chez vous une foule de gens qui, après des insuccès répétés, ont refait leur situation jusqu'à trois ou quatre fois, recommençant en quelque sorte leur vie à nouveau, acceptant de redevenir apprentis ou modestes employés pour prendre un nouvel essor.

Cette énergie, cet optimisme, cette persévérance vous ont été d'autant plus utiles qu'il s'agissait de transformer un pays neuf, un pays imparfaitement connu, sur lequel il était inévitable que quelques erreurs d'appréciation fussent commises. Mais vous aviez la bonne fortune d'être affranchis des conditions étroites que font à la plupart des peuples européens le lourd héritage de leur passé, les responsabilités et les dettes qu'il leur a laissées. Vous avez eu la bonne fortune de pouvoir bâtir votre édifice sur un sol presque ras, en même temps que vous avez profité de nos efforts séculaires. Libres des contraintes du passé, vous avez pu marcher d'un pas plus rapide que nous vers l'épanouissement de toutes les forces scientifiques et de tous les progrès pratiques. Vous n'avez été entravés, ni par la bureaucratie tracassière, ni par le fonctionnarisme étroit qui recouvrent, comme d'un réseau à mailles serrées, les institutions des pays européens et empêchent fréquemment l'épanouissement de l'esprit d'initiative.

Vous possédez aussi une qualité qui frappe vivement un Français: je veux parler de votre amour de la liberté et de votre esprit de tolérance. Il n'y a pas un pays de l'Europe où l'on soit aussi respectueux qu'ici des opinions, des idées, des convictions, quelles qu'elles soient.

Cet esprit de tolérance s'explique essentiellement par l'intelligence plus parfaite que vous avez de la véritable démocratie. Au lieu d'évoluer, comme dans la vieille Europe, vers une sorte d'étatisme inquiétant pour l'avenir, la démocratie apparaît ici vraiment comme l'état social qui tend à porter à son maximum la conscience civique et le sentiment de la responsabilité, de deux choses qui n'existent qu'incomplètement en Europe par suite de l'organisation administrative de la plupart des Etats. La démocratie américaine apparaît aussi comme une manifestation de cette idée que les hommes étant semblables on n'a pas le droit de distinguer entre eux; et c'est pour cela qu'il n'y a pas de pays où, pour juger un homme, on se préoccupe moins qu'ici de son origine, de son instruction, du métier même qu'il a embrassé; il n'y a pas de pays où l'homme le plus humble puisse devenir plus vite et plus aisément un facteur de l'organisation sociale. Et la liberté d'action laissée à l'individu contribue au développement et à l'expansion de son être tout entier, elle amène vite l'homme à reconnaître que pour se sentir libre lui-même, il doit en premier lieu respecter et protéger la liberté des autres.

Comment ne pas admirer aussi l'esprit de concorde, le sentiment de solidarité, qui forme peut-être le trait le plus caractéristique de la vie américaine et qui exerce sur les immigrants, d'où qu'ils viennent, une si profonde attraction. Allemands ou Français, Suédois ou Polonais, Suisses ou Irlandais conservent sans doute nécessairement quelques-uns des signes distinctifs de leur pays natal, mais ils sont bien vite unis comme les citoyens d'une même patrie, et au bout d'une génération les enfants de ces Européens sont tous des Américains aussi ardents

dans la sincérité de leur sympathie, aussi fiers de leur nationalité nouvelle que ceux qui sont Américains depuis plusieurs siècles.

II. Au sentiment d'admiration dont je viens d'indiquer quelques-unes des causes s'ajoute un sentiment de crainte: vous nous apparaissez comme "le pays des possibilités illimitées." Comment ne pas être un peu effrayé lorsqu'on envisage les ressources prodigieuses dont vous disposez. Vous avez d'abord une situation géographique incomparable, à cheval sur les deux océans entre lesquels se partage déjà et se partagera de plus en plus, au cours du siècle qui vient de s'ouvrir, l'activité économique de l'humanité. Votre sol se prête aux productions les plus variées—blé, seigle, orge, avoine, riz, maïs, coton, pomme de terre, sucre, tabac et houblon y poussent à merveille suivant les contrées; votre sous-sol renferme des richesses incalculables. Déjà vous avez enlevé à l'Angleterre la double royauté de la houille et du fer et vous serez bientôt aussi probablement le premier pays du monde pour l'industrie textile, car vous n'êtes pas seulement les grands producteurs de coton, nous pouvons à bon droit redouter que vous n'arriviez à consommer dans vos usines la plus grande partie de vos récoltes.

Vous avez inauguré une nouvelle période dans l'histoire économique contemporaine. Comment le vieux monde ne serait-il pas inquiet en voyant dans quelle mesure vous l'inondez de vos grains et de vos farines, de vos animaux vivants et salés, de vos houilles qui viennent disputer aux houilles européennes les marchés de la Méditerranée, de vos machines, de votre verrerie, de vos produits chimiques. Les statistiques prouvent que vous n'avez pas seulement enlevé aux produits similaires de l'Europe une partie de leurs anciens marchés, mais que vous commencez à pénétrer partout dans l'Europe elle-même. Il y a plus, les matières premières que vous recueillez sur votre propre territoire ne suffisent déjà plus à votre dévorante activité, vous allez maintenant les recueillir sur les marchés que l'Europe s'était jusqu'ici réservés. L'Angleterre, l'Allemagne, la France ne sont plus seules à acheter les peaux et les laines de la République Argentine ou le caoutchouc du Brésil; 7,000,000 de kilos de soie brute sont annuellement enlevés au Japon et à la Chine pour les usines du New-Jersey. Et pourriez-nous nous reprocher de ne pas nous montrer inquiets du développement que vous avez donné à la doctrine de Monroe? Avons-nous tort de penser que les Antilles européennes sont aujourd'hui menacées? Avons-nous tort de croire que vous désirez le contrôle de la route New York-Sydney? Avons-nous tort de supposer que vous convoitez une extension nouvelle de votre horizon politique? Quelques-uns de vos écrivains ne nous parlent-ils pas de la "yankisation" du nouveau continent tout entier, d'autres même de l'américanisation du monde? "Notre nation," écrivait naguère un éminent

évêque, Monsignor Ireland, "sera la reine, la conquérante, la maîtresse, l'institutrice du siècle à venir."

III. Aussi la crainte que vous inspirez à la vieille Europe a-t-elle développé dans nos esprits le désir de découvrir les points faibles de votre civilisation et de critiquer quelques-unes de vos idées. Nous rendons hommage à votre optimisme, à votre confiance en vous-mêmes, mais à votre ardeur au travail nous sommes un peu choqués en voyant à quel point vous êtes préoccupés par le progrès matériel sous toutes ses formes, par la poursuite incessante de la richesse et des satisfactions qu'elle procure. Nous ne pouvons pas, tout en admirant vos progrès industriels, ne pas nous élever contre ces "trusts" qui ont été un si puissant instrument de succès pour vous, et cela, non parce qu'ils ont été des moyens de guerre dont l'Europe à pu souffrir, mais parce qu'il n'y en a pas un où les choses se soient passées honnêtement, et aussi parce qu'ils ont favorisé la corruption parlementaire et accru le rôle des politiciens dans votre pays. Il nous semble aussi que ces "trusts," qui ne sont pas une application "nécessaire" de la loi de concentration économique, ont finalement procuré à un nombre restreint de personnes des bénéfices trop considérables qui n'ont été en rapport ni avec le mérite, ni avec la véritable supériorité des metteurs en œuvre qui en ont presque seuls profité. Et nous critiquons aussi en Europe les défectuosités de votre vie de famille, les exagérations de l'esprit d'indépendance dont votre jeunesse est animée et qui explique sans doute les progrès considérables qu'a fait chez vous le divorce.

En dépit de ces critiques, que vous nous pardonnez en pensant que nous aimons à nous critiquer nous-mêmes, nous n'en sommes pas moins pénétrés d'admiration, de respect, de sympathie pour cette grande nation des Etats-Unis, qui donne aux peuples européens tant d'exemples bons à méditer, qui, mieux qu'eux, peut-être, sait faire un bon emploi de ses ressources et de ses qualités, qui donne en tout cas un magnifique exemple d'action, de résolution, d'énergie vraiment virile. Nous avons beaucoup à apprendre de ceux qui savent si bien organiser le travail, si intelligemment développer les sources de leur richesse et de leur puissance, qui se montrent comme d'admirables professeurs d'énergie et comme les prototypes d'une humanité d'un plus grand modèle.

THE CABOT LANDFALL

By G. R. F. PROWSE, Brandon, Manitoba

The discovery of the American littoral falls naturally into two divisions, radiating from the epoch-marking advent of Columbus in the West Indies in 1492, and the fully authenticated voyage, but very obscure landfall, of John Cabot five years later. Students have attempted to settle this question of Cabot's landfall by an analysis of the contemporary accounts and by a study of early cartography. Both methods have in the past led to some very remarkable conclusions. By the historical method the area within which the landfall must fall can, I believe, be reduced to very narrow limits, which I shall consider later on. My paper, however, is mainly devoted to a consideration of the cartographical evidence. John Cabot made a map and a globe showing his first discoveries, but they have not been preserved, at least in their original form. We are compelled therefore to scrutinize the more complex maps which have survived for evidence of his landfall.

There are only two charts whose history and construction are sufficiently authenticated to serve as the basis for deductive work—the Cosa map of 1500 and the Cantino of 1502.

Amid much that hitherto has been unintelligible, the Cosa shows unmistakably the results of English exploration on the northeast coast prior to June, 1500. The Cantino map, on the other hand, covers with Portuguese flags that portion of Newfoundland and Labrador portrayed on it and brings it within that country's sphere of influence, as defined by the papal bull.

Practically, therefore, all speculations as to the courses of John Cabot in 1497 and 1498, from those of Humboldt to those of Dawson and Archbishop O'Brien, none of which have been generally accepted, have been based upon the Cosa map.

No attempts have been made, doubtless on account of the Portuguese claims, to approach the discoveries of Cabot by an analysis of the Cantino map. I propose to ignore the indications of Portu-

guese sovereignty on this map and examine it upon its merits cartographically.

I am not aware that there has been any exact delimitation of the coast line of the Cantino map so far as it relates to the northeast coast. In the extreme north, on what is undoubtedly Greenland, are two Portuguese flags and an inscription which declares inter alia that the Portuguese saw this country but did not enter it. On the Munich, 1515 (Kuntsmann No. 4), map an identical legend is on Do Lavrador. The land of Labrador can be shown by a continuous series of maps to be the coast of northern Labrador from about 56° north latitude to a point near Hudson Strait. Further, there is very little reason to doubt that this land covers the whole exploration of John Cabot in 1498. When, moreover, we find no indication whatever of any original post-Columbian exploration of Greenland in the early part of the sixteenth century, the similarity of the inscriptions on the Cantino (1502) and Munich (1515) maps forces me unhesitatingly to the conclusion that the flagged part of Greenland on the Cantino map is acutally meant for part of Labrador.

Whether this coast is part of Labrador or Greenland, the discovery of Cabot in 1498 or of Cortereal in 1501, we can at once exclude it from our consideration of the 1497 landfall, as the caplin and cod, so prominently mentioned in the contemporary narrative, never reach this region early in July. It is also absolutely impossible to approach this coast in June without encountering ice, which we may be fairly sure would have been noticed and commented upon if it had been seen.

Southwest of Greenland or Labrador on the Cantino map lies the Terra del Rey du Portuguall, just east of the papal line. This coast extends from Sandwich Bay, Labrador, to Cape Anguille. This same outline was employed on practically all maps of the sixteenth century. The western termination at Cape Anguille, near Cape Ray, is so obvious that it needs no detailed examination. The northern extremity on all maps showing the Cantino configuration is invariably associated with the five place names given on Reinels's 1505 map—"y da fortuna," "y da tormenta," "c do Març̧o," "Sam Johan," and "Sam Pedro," and on later maps with "S. Maria." The last three have disappeared from modern maps, but "y da tormenta" and "c do Març̧o" are probably represented to-day by "Devil's Lookout I." and "Mark I." "Y da fortuna" is the "Terre Nova Point" of Table Bay or the "Newfoundland I." of Sandwich Bay. Whatever may be the exact equivalents of these original names to-day, there can be no doubt that the Cantino coast extended to about Sandwich Bay, as a careful examination of the contour of the whole coast line shown on this and subsequent maps leads to exactly the same result.

Having established the extent of the "Terra del Rey du Portu-

guall," we have to determine whether this survey is the result of one voyage or of several independent explorations coordinated into one continuous coast line.

The first point to which I wish to draw your attention is that, in spite of the Portuguese claim, the Cantino map must show more than the voyages of Cortereal, the only explorer of this nationality who is known to have been on this coast up to 1501, for we are expressly told that his 1501 voyage was not continuous with that of 1500.

Secondly, the coast line from Sandwich Bay to Cape Anguille on the Cantino map is too long, extending as it does a distance of over 1,200 miles, and too correctly and minutely shown to have been the work of Cortereal in 1500 and 1501; he could not have covered the distance in the time of his known absence from Europe.

Thirdly, with the aid of several maps of uncertain but very early dates we can analyze the "Terra del Rey du Portuguall" into four independent parts, which I have named Sandwich, Northern, Notre Dame, and Eastern or Conception.

That the Cantino map is composite is the only possible explanation of the fact that it can be constructed in the main from smaller units of coast.

The Sandwich section is peculiar to the Cantino map and records a voyage subsequent to the others; the Notre Dame and northern sections, as shown on the Munich 1502 and Pilestrina maps, have been modified more or less by the Cantino surveyor, so that the identity of the configuration may be questioned; but the eastern section of the Pilestrina and Cantino maps are absolutely identical, and on the former this section is joined to the Notre Dame in such a manner as to completely preclude the possibility of their being the result of one continuous exploration. If, as I have every reason to suppose, the outline of this eastern section is not the result of an entirely independent exploration, but simply a secondary voyage which modified the Conception sections of the Oliveriana and Cosa maps, the original voyage upon which the Cantino eastern is based must have occurred before Cortereal reached the coast, and must therefore be the work of Englishmen. The Cosa flags support this view. As this Conception voyage lasted apparently from December 8 to at least October 23 of the following year it can not be Cabot's of 1497.

It can also be clearly proved that the Notre Dame section shown on the Munich 1502 and Pilestrina maps is the record neither of Cabot's 1497 voyage nor of Cortereal in 1500, though it probably limits the extent of this latter voyage. Six of the seven Portuguese names on the Pilestrina map can be identified with modern English names on the coast, and as the modern names appear to be the only ones used for these places I consider it altogether improbable that the names

which should accompany the Munich survey were different from those found in Pilestrina. Two of these, "Ilha emcorporada" and "Rio de rosa," stand for "Good Friday" and "Easter Sunday," dates at which neither Cabot in 1497 nor Cortereal in 1500 or 1501 could have been on this coast. As this Munich 1502 map shows one of the very earliest voyages, there is every reason to assume it was made in 1498, probably by Cabot's partners, who we know were determined to return to the land discovered in 1497.

As the northern voyage is evidently of later date than the Notre Dame, for both the Munich and Pilestrina maps show the latter and only the Pilestrina the former, it can not be the record of the 1497 voyage; and as it joins the Notre Dame coast within which we are entitled to place Cortereal's exploration of 1500, it can not be a Portuguese survey.

The Sandwich is so evidently the latest of these four voyages shown on the Cantino map that we may dismiss it at once as not Cabot's in 1497; and although it most probably covers Cortereal's 1501 exploration, it can not have been his survey, for it evidently records a voyage begun in March and continued southward to join and overlap the known northern and Notre Dame explorations. Reinel places an English flag at the northern end of the Sandwich survey.

It is clear, then, to my mind, that not one of the four sections of the Cantino map is the work of Portuguese explorers, and that none of these sections show the actual coast examined by Cabot in 1497, although they must all have been the work of Englishmen. Although Cortereal certainly came to this coast in 1500 and 1501, I have come firmly to the conclusion, difficult as it may be for cartologists to accept it, that on neither occasion did Cortereal make any independent survey, but that rather his purpose was to prospect the country and report its value to the Portuguese King.

If the Cantino map, however, shows only the results of English exploration prior to 1501, there is every reason to conclude that somewhere between Sandwich Bay and Cape Anguille lies the landfall of Cabot in 1497. There is every reason to suppose, also, that it will fall within that section which appears to have been first discovered. This excludes at once the Sandwich and northern sections, and we are left to choose between the Notre Dame, as shown on the Munich, and the Eastern. As the Eastern most probably shows a second voyage, based upon the "Conception" of the Oliveriana map, we have to decide which of the two maps—the Munich 1502 and the Oliveriana—both apparently showing primary voyages, is the earlier. They were probably almost contemporary, but made by independent explorers. As, however, the "Insula de Laborador" of the Oliveriana map is most probably meant to represent the Cabot's 1497 voyage, it seems very unlikely that the landfall lies within the Conception sec-

tion. This "Insula de Laborador" can be connected doubly with Cabot. It is of exactly the same form as the "I. Antilia," or "Seven Cities," which Ayala says Cabot was in search of and Sonsino says he found, and also of the St. John Island, which is directly connected with the landfall on the S. Cabot 1544 map. If the Burgundian who accompanied Cabot in 1497 was an Azorean named Labrador it furnishes an additional connection with Cabot. The similarity in shape of "I. Antilia" and "St. John I.," found on maps as early as 1505, by Reinel, removes all doubt as to the correct date of the landfall, June 24.

The island on the Cosa map opposite the Notre Dame coast is apparently intended to represent this same Cabot island, and it may perhaps be presumed that it is not within the Conception coast: there is also some evidence that it was traditionally connected with the Notre Dame coast on maps rather closely allied to the Cosa map. Dudley has "C. S. Giovanni" for "Cape St. John," "S. Jones" for "St. John's Harbour," and an "I. S. Juan" opposite "Ferryland." Bleau, 1659, amid much confusion of names, marks "Baccalieu I.," "I. S. Jean;" and Champlain, 1612, has "St. Jean" opposite "St. Johns Harbour." Champlain is dubious, and might support Archbishop Howley's theory of a St. Johns Harbor landfall, but Bleau is less so, and in Dudley we have the curious circumstance that the three St. Johns are in three distinct languages. Taken together, I connect these St. Johns islands with an old tradition connecting Cabot's landfall with the coast north of Cape Race to the exclusion of the south coast.

By a process of elimination we have arrived at the conclusion that the landfall must lie north of Cape Race, within the Notre Dame section which extends from Notre Dame Bay nearly to Cape Race.

Before proceeding to examine what cartological evidence is available to directly connect Cabot with this region in 1497, it will be as well to consider here the bearing of the historical contemporary narratives and climatic conditions upon the landfall.

Leaving Bristol early in May, Cabot sailed north for some time after rounding Ireland and then turned west. On this course the landfall must either have been on Labrador or the east coast of Newfoundland. We can exclude all Labrador and Newfoundland north of Cape Freels, for the simple reason that in June and early July there is always ice on this coast, and we may be sure the contemporary narrative would have noted such an extraordinary phenomena as floating ice and icebergs if they had been met with. The accounts of the second voyage all mention ice. The conditions of the north Atlantic in June, therefore, narrows the landfall to the coast between Cape Freels and Cape Race. The description of the fishing, the abundance of cod, the caplin school, whence fish were taken, as to-day,

in hand nets, all point to this shore. We have also the corroborated statements of both Spanish and Italian correspondents that the new land was only 400 leagues from Ireland.

This is as far as the landfall controversy can be carried by the broader historical and cartological evidence—it all points to the coast between Cape Freels and Cape Race. Continuous Newfoundland tradition places the landfall within this region, at Cape Bonavista. This tradition is incidental and not tainted, as the Cape Breton tradition of Sebastian Cabot may have been, by political motives. It was probably carried down for several generations solely by a few families directly connected with the first voyage and engaged in the Newfoundland trade. Mason's map, as early as 1617, records this tradition. The well-known Capt. John Mason, one of the founders of New Hampshire, a scholar, and governor of Newfoundland from 1615 to 1621, took an intelligent interest in such questions, as similar investigations undertaken by him later on in New England show. He afterwards became treasurer of the royal navy, and was employed by Laud on several important occasions. Whether this information came to Mason from fishermen on the coast (two generations would suffice to carry on the tradition), or he found it on the map from which his own was engraved, his record of the Bonavista landfall is the most direct and weighty historical fact in this controversy. It is astonishing that the evidence of a man of his position and opportunities has been treated so lightly. We can not, of course, overlook the fact that the Cape Breton landfall was accepted generally by Elizabethans and even by Hakluyt, for a time at least. It, however, receives no support whatever from history or cartology.

The Bonavista tradition has not received general acceptance for three reasons: The counterclaim in favor of Cape Breton, the failure to connect this neighborhood in any way with Cabot, and the absence of the name St. John the Baptist at this point. I think there can be no doubt Cabot's 1497 coast was named St. Johns Island.

Dealing with the last point first, in addition to the St. John Island previously mentioned, we find on the Maggiolo map a "B. de S. Zacharia," the Baptist's father's name, and a "Rio de Jordan," the Baptists River in Bonavista Bay. This latter probably renders intelligible the "St. Johns River" of Cuelen's and Visscher's maps, and offers one solution of the confusion of names on such maps as the Barlow, where Cape St. John appears twice.

The Cuelen and Visscher maps deserve very close study. The similarity of their coast to the actual coast west of Blackhead Bay to Clode Sound may be accidental, though it never appears on any other map. The significance of the river St. John may also be important, as it appears on the Dudley map also west of the real Cape

St. John, but the names Bonani and St. John (town) give a most archaic character to these maps and indicate to my mind their derivation from a most ancient type.

After all, however, it is most difficult to understand how such an important name as this St. John, connected by local tradition with the first discovery of the island, so completely disappeared, with one or two exceptions, from all ancient and modern maps.

Apart from Mason's inscriptions, we may trace a connection with Cabot in the name Castaleon, now Castle Bay, in Bonavista Bay. This may record his birthplace or the name of his barber, Castiglioni. It may be only a Castile territorial mark.

The Cape Breton landfall is untenable, not only on account of the improbability of such a landfall from the course taken by Cabot, but also because Nova Scotia does not appear upon early maps until after the Newfoundland and Labrador coast had been explored.

After maintaining a suspended judgment on this landfall question for over twelve years, I am now convinced that this continuous Newfoundland Bonavista tradition, supported by Mason in 1617, will eventually be accepted by all historians. I can not see where any evidence can be brought from to place it outside the coast from Notre Dame to Ferryland—all that is shown of Newfoundland on the Munich 1502 map, the simplest cartographical unit which has come down to us. There is no tradition or evidence that points to any other place within this area. The landfall at Bonavista is perfectly consonant with the contemporary narratives; it involves no unnatural agreement, as the Cape Breton one does, as to the course; and it agrees with the more conservative estimates that its distance was 400 leagues from Ireland, and with the time—fourteen days—Cabot evidently took to return to Bristol in 1497.

All available evidence points most strongly to the conclusion that Cape Bonavista was the first land seen in the New World by John Cabot and his Bristol associates on June 24, 1497.

Turning for a moment to the general cartology of the northeast coast, I may remark that the weight of my arguments is very much strengthened by the fact that the coastal configurations of the maps reviewed—the Munich, Pilestrina, Freducci, Oliveriana, Cosa, and Cantino—were employed in general outline in various combinations for all known maps up to 1760. This persistence of type very much strengthens the conclusion I have reached that all the coast from Cape Chidley to Cape Sable, including the Gulf of St. Lawrence, was explored by Englishmen by 1501 at the latest.

The elucidation and accurate determination of these earliest voyages can not be a matter of indifference to historians. A clear conception of the continent known to the pilots of Verrazano Gomez

and Rut, Ribalt and Raleigh, Gosnold and De Monts, is essential to complete the early history of the New World.

The half-forgotten wanderings of the trader-fisherman lend an air of mystery and enchantment to the background of that imposing picture. Harbingers of a new and mighty civilization, "they builded better than they knew," as in eager expectancy they rounded headland after headland. No poet has arisen to immortalize their deeds in an epic, but the industry of Biddle and many worthy successors is rendering it possible to follow their movements with ever-increasing precision.

SOME EARLY GEOGRAPHERS OF THE UNITED STATES

By Rear-Admiral C. M. CHESTER, U. S. Navy

On an occasion like the present, when distinguished men from all parts of the world meet together to consult with reference to the means for promoting the great objects for which our individual societies were inaugurated—a study of the earth and its inhabitants—it seems fitting that we should take at least a cursory glance at the work which has been done by our forebears in the way of collecting geographical data in order that we may plan for its future development, for it is history that must form a basis for all advancement.

In these strenuous days, when by the means of modern appliances so much is accomplished in a short time, we are apt to forget to what extent we are indebted to the pioneers in new fields of discovery, who by their labors have given to mankind such indescribable benefits, including untold millions of money. Such a matter of course has it become, that geographical expeditions are now fitted out, even for the antipodes, with only a brief notice in our daily papers, while any story, however unimportant, provided its effect is to startle the mind, is given space ad libitum, and in many cases ad nauseam.

It is therefore to such societies as we greet to-day in this city, which is celebrating one of the principal events in geographical history, that we must delegate the duty of stimulating our people to further efforts at research in the special field of science which we have met to consider, with the assurance that as long as "knowledge is power" no region that is unknown can be too unimportant for investigation.

This must be my excuse for taking up a portion of your time with a résumé of a part of the work done in this cause by the service to which I have the honor to belong, the Navy of the United States. To cover the whole field of geographic exploration in a lecture of a few minutes is not within the power of any man, and hence I have restricted myself to the early achievements of this small corps of men with whose accomplishments I am best acquainted, and even as thus circumscribed I must confine myself to a bare outline of the reports made, leaving to better hands much to be mentioned.

I think I may say that the United States Navy is one of the oldest, if not the oldest, of all the national geographical societies of this country,

for scarcely had we become a nation before its officers began a study of our coast, near which in the early days of the Republic most of its population resided, and of which very little was known. The summation of the information then extant was given in a few incomplete charts, so unreliable as to be practically useless, handed down from the early surveys, or rather reconnoissances, of our English ancestors. As our own coast became more familiar to the people, naval officers began to glean in other fields, and no part of the earth's surface was too distant to claim their attention.

This resulted in establishing within our naval administration a department which was known at first as the United States Naval Observatory and Hydrographical Department, and which has given to the world a vast amount of data gained from surveys or investigations made in almost every country in the world. And we must remember that, as Humboldt has placed on record, the world is indebted to the United States Navy for founding a new department of science, that of the physical geography of the sea.

Few names stand higher on the roll of honor and few men have lived whose work has been of more lasting benefit to mankind than that of the distinguished scientist, Commander Matthew F. Maury, late United States Navy, who was the originator of and most valuable contributor to this branch of science.

SLACUM'S VOYAGE

In November, 1835, President Van Buren directed William A. Slacum, an officer of the United States Navy, to proceed to the western coast of the United States and endeavor "to obtain there all such information, political, physical, statistical, and geographical, as might prove useful or interesting to the Government."

Slacum traveled through Mexico to Guaymas, and left that port on the 1st of June, 1835, intending to reach Oregon by land; but being informed of the impracticability of using the land route at that season of the year, he proceeded by sea, and after many vicissitudes reached the mouth of the Columbia River December 22, 1836. Here he surveyed and plotted a chart of the mouth of that river, and also compiled a chart of the coast and country south of the Columbia. The four rivers, Klamath, Coos, Rogue, and Umpqua, which had never before been charted, appear on this map and were thus made known to geographers through his efforts.

WILKES EXPLORING EXPEDITION

The most complete exploring expedition ever fitted out from America, up to the time of its departure, was that which left the United States in 1838. The expedition sailed under the command of Lieut. (afterwards Rear-Admiral) Charles Wilkes, U. S. Navy,

who was aided by a most intelligent band of officers well prepared for its onerous duties. The difficulties which attended Wilkes's expedition can hardly be conceived at the present time, when steam relieves the sailor of many cares and guards him from numerous dangers against which his predecessor had to battle with sails only.

On August 19, 1838, the vessels left Chesapeake Bay, and, after stopping at Madeira and the Cape Verde Islands, arrived at Rio de Janeiro, Brazil, from which they sailed on the 6th of the following January. From Rio de Janeiro they proceeded to Rio Negro, in Patagonia, and to Nassau Bay, in Tierra del Fuego, from which two schooners attached to the expedition made cruises in different directions toward the South Pole. One of these, the *Flying Fish*, reached latitude 70° 14′ south, nearly the highest latitude attained by Captain Cook and not far from the longitude reached by him; but the season had already advanced too far for the best results, and they rejoined the squadron at Valparaiso in May, 1839. The *Vincennes* in the meantime was occupied with a survey of Nassau Bay. The schooner *Sea Gull* was lost in a gale soon after leaving Nassau Bay.

From Valparaiso the vessels sailed to Callao, Peru, where the *Relief*, being ill-adapted to the voyage, was sent to the United States.

On the 12th of July the squadron left the coast of South America and visited and surveyed fourteen or fifteen of the Paumotu Islands, two of the Society Islands, and all the islands of the Navigator Group, and reached Sydney, New South Wales, on the 28th of November, 1839.

The vessels next proceeded on their second Antarctic cruise, discovering land in longitude 160° east and latitude 66° 30′ south.

It should be said of Wilkes's discoveries in Antarctica that the recent expeditions of Captain Scott, of the British Antarctic expedition; Doctor von Drygalski, of the German; Captain Bruce, of the Scottish; and Captain Nordenskjold, of the Swedish, all confirm the correctness of Admiral Wilkes's work in the frozen south, and, as Mr. Edwin Swift Balch said in a recently published article in the National Geographic Magazine, they "show what a remarkably acute and accurate geographical observer Admiral Wilkes was." Let us not forget, in our felicitations to these gallant voyagers of the present generation, how much we owe to the intrepid pathfinder who, in 1840, first announced to the world his discovery of the Antarctic continent, nor the fact that his almost miraculous voyages were made in ships some of which would hardly be trusted outside of port at the present date.

In the course of the expedition about 280 islands were surveyed, 800 miles of hydrographic surveys were made on the streams and coast of Oregon, and 1,500 miles along the land and ice barrier of the Antarctic continent. Numerous islands of doubtful existence were

searched for, shoals examined, and reefs discovered and charted: many harbors were surveyed, and several were for the first time made known to the world. The latitudes and longitudes of the ports visited were determined with all possible precision, and a large number of the doubtful points in the geography of the Pacific were cleared up. All this work was attended by innumerable dangers on land and on sea. The personal adventures alone would fill a volume both startling and interesting in the extreme.

The large number of charts produced from the records of this cruise evince alike the energy and industry of the commander and all his assistants.

As a sequel to the Wilkes expedition might be mentioned an examination of the Te Pito Te Henua (Easter) Island, in the South Pacific Ocean, which took place under Lieut. (now Rear-Admiral) F. M. Symonds, U. S. Navy, while on duty as navigator of the U. S. S. *Mohican* in 1887. The expedition was mainly in the interest of ethnology and general prehistoric data, but a large amount of geographical literature was added to the store of the Navy Department and published on the charts of the Hydrographic Office. The *Mohican* brought back to Panama the famous Easter Island statue, and the U. S. S. *Galena*, which vessel I had the honor to command, continued its voyage for the Smithsonian Institution, and gathered data for the scientific literature of that institution.

EXPEDITION TO THE DEAD SEA

One of the early scientific expeditions fitted out by the United States was that for the exploration of the Dead Sea. It was purely a naval expedition, and the selection of this branch of the public service to do the work was wise and economical. By education and familiarity with instruments of precision, naval officers were well fitted to make the surveys and handle the delicate questions of international comity that were likely to arise at that time in a country as turbulent as that ruled by the Ottoman Government, with which the commander of the expedition was required to deal. Furthermore, the general handiness and adaptability of the sailors, as well as their military training, made them singularly well suited for this work.

Lieut. W. F. Lynch, U. S. Navy, was placed in charge of the expedition, and, indeed, he might be said to have conceived it. He was assisted by Lieut. J. B. Dale and Passed Midshipman Richmond Aulick, U. S. Navy, two most efficient young officers. The U. S. S. *Supply* was designated to carry the party to Syria, and left the United States for its destination November 26, 1847.

This novel expedition returned to the United States after an absence of nearly a year, its officers and men having overcome almost

insurmountable difficulties. One of the officers, Lieutenant Dale, unfortunately succumbed to the fatigue, privation, and sickness incident to the cruise and gave up his life to the cause.

Besides a report that may be considered classic in character, Lieutenant Lynch brought back with him a large number of specimens pertaining to many of the sciences allied to geography.

The volume comprising the summary of the researches made by the intelligent officers of the party may be found in nearly every scientific library of the country.

EXPLORATION OF THE VALLEY OF THE AMAZON

In 1850 Lieut. William L. Herndon, U. S. Navy, who had made a reputation as an explorer by very considerable service in Chile, was sent by the United States Government to explore the valley of the Amazon. He directed his course over the Andes from Lima, Peru, and, reaching the headwaters of that river, followed it to the sea. The object of the expedition was to ascertain the resources and future capabilities for trade and commerce of that immense watershed.

Lieutenant Herndon's valuable and instructive report was published by Congress and has remained ever since the foundation for different expeditions, some of which will be referred to later.

He ran a line of soundings from the source of the Amazon, among the mountains, to its mouth in the Atlantic Ocean, and found it navigable for vessels of the largest class from the sea to the base of the Andes, a distance of nearly 3,500 miles. He also determined the geographical positions of important points at many places along its banks.

His assistant, Lieutenant Gibbon, also of the Navy, taking a more southerly route, embarked upon the Mamore River at Cochabamba and descended that river to the Madeira and thence to the Amazon.

On two later occasions the Government of the United States sent expeditions to survey this river. The first, in 1878, consisted of the U. S. S. *Enterprise*, under Commander (now Rear-Admiral) T. O. Selfridge, U. S. Navy. From the results of this work the Navy Department published navigation charts of the Amazon up to the bar of the Rio Negro, and of the Madeira up to the falls of San Antonio. These charts are now used to navigate the ships of nearly every country of the world doing business in the basin drained by this mighty river.

The next expedition was under the command of Capt. C. C. Todd, of the U. S. S. *Wilmington*, which steamed up the river as far as the city of Iquitos, a distance of nearly 2,400 miles, arriving there on the 23d of March, 1899. Captain Todd's report is replete with valuable information of a practical as well as of a scientific character, and the Navy Department has made extensive use of it.

The pathfinder in these waters, Herndon, ended his life in one of the most gallant and tragic episodes of the Navy, going down with the steamship *Central America*, which he commanded, after refusing to get into the last escaping boat lest its capacity might be overfilled.

EXPLORATIONS IN THE RIO DE LA PLATA

Commander T. J. Page, U. S. Navy, in the U. S. S. *Water Witch*, with a complement of intelligent officers, was in the year 1854 engaged in an exploration of the Rio de la Plata and its tributaries. Owing to his tactful association with the citizens of the valley of that wonderful river, his labors resulted in a most valuable contribution to our geographical knowledge of the whole watershed drained by it.

This great river system had just been opened to commerce, and the voyage of the *Water Witch* proved to the world that ocean-going steamers could ascend the Parana and Paraguay rivers to a point 700 miles above Ascuncion, a city that is itself as far from the sea as St. Louis is from the Gulf of Mexico.

During the progress of this important survey daily astronomical observations were made, soundings were taken and charted along 3,600 miles of river bed, much of the surrounding country was explored, and natural history collections were made that were of great value to science, art, and commerce.

ASTRONOMICAL EXPEDITION TO CHILE

Lieut. James Gilliss (afterwards commodore), U. S. Navy, who was the founder of the United States Naval Observatory and who published the first American volume of astronomical observations, was also a large contributor to our geographical literature.

While he was director of the astronomical expedition to Chile in 1853, he was industriously engaged in collecting data touching the geography and statistics of that interesting country. One of his associates, Lieutenant McRae, U. S. Navy, crossed the pampas to Buenos Ayres, procuring matter of great interest for his report of the trip. On a later voyage he made further investigations regarding the interesting section through which he had passed.

By the combined efforts of Gillis and McRae the common geographical treasury of the world was largely enriched.

EXPLORATION AND SURVEY OF THE PANAMA ISTHMUS

Many attempts were made to explore the almost unknown region of the P[illegible]ma Isthmus before the middle of the nineteenth century without [illegible]ging more than negative results; but the growing importanc[illegible] the commerce of the United States created a strong

desire on the part of the American people to break the barrier separating the two oceans which bound this country.

The Navy of the United States, whose main duty in peace times is to carry the flag into distant countries, was naturally selected to explore the Isthmus of Panama, and wiliing leaders were found to attempt to make a passage through the almost impenetrable forests of that wild country.

The first requisite of a canal which would carry our ships from ocean to ocean was not only a crossing, but the lowest crossing that could be found; and as the axiomatic statement that "the bed of a stream or river furnishes the line of lowest levels in the basin drained" was early propounded as the basis for the exploration, the wisdom of selecting the "hydrographers" of the country to do the work was self-evident.

It might be said that the commander in chief of all the expeditions which operated on the Isthmus was Rear-Admiral Daniel Ammen, U. S. Navy. From the very beginning of the systematic investigation of the problem to which an answer has at last been found he took great interest in it; he hammered at the problem early and late until the day of his death. Balked in his desire to personally lead a party in the field, he used the commanding influence of his great friend, President Grant, who had called him to Washington mainly because of his extensive knowledge of this subject, and he was instrumental in fitting out several expeditions to survey routes for the canal.

A detailed account of the surveys made on the Isthmus of Panama by American naval officers is not needed to show how much the final project to join the Atlantic and the Pacific oceans owes to them its present promising condition; and indeed I must content myself with barely mentioning the names of some of the gallant officers engaged in this important undertaking, beginning with Lieutenant Strain, U. S. Navy, whose attempt at exploration was made in 1844. Lieutenant Strain's expedition was unfortunate in its personnel, but the information acquired, though negative, was of great utility, for a final conclusion as to the relative advantages of the many routes presented to geographers for discussion was reached only by a process of elimination. Strain proved that the Darien route was impracticable, and, notwithstanding the mishaps of the party, the results obtained created such emulation among his brother officers that they never let the matter drop until the final plans for building the "world's canal" was completed.

The name of Lieut. T. A. M. Craven might also be mentioned in connection with the early explorations of the Isthmus, although his work consisted mainly of hydrographic surveys and the verification of the data collected by other hands.

At the present time the distinguished naval officer, Rear-Admiral John G. Walker, U. S. Navy, who followed Admiral Ammen in office as well as in his zealous advocacy of the scheme, is president of the Isthmian Canal Commission which is to bring this wonderful undertaking to a final completion.

The first of the fully organized surveying parties to enter the field for canal exploration was the Darien expedition, under the command of Commander T. O. Selfridge, U. S. Navy. This expedition examined the Caledonia, Morti, and San Blas routes and the next year (1871) surveyed the Atrato-Peranchita-Tuyra route. These surveys settled many questions touching the practicability of building a canal.

Capt. R. W. Shufeldt, U. S. Navy, in 1870, ran a level and transit line from Salina Cruz, on the Pacific, to the junction of the Blanco and Corte rivers, to develop the Tehuantepec route, but found it impossible, with his limited force, to continue the line to the Atlantic. The information obtained, however, in connection with the results of the desultory examinations previously made, gave a very good idea of what the route was to be.

The Lake Nicaragua route, which was for a long time a favorite field for study, was thoroughly examined by several parties, the first being in charge of Commander A. F. Crossman, U. S. Navy, whose untimely death by drowning in the surf on the bar at Greytown disturbed for a time the progress of the work. Commander Chester Hatfield, his successor in command, then made an incomplete survey of Lake Nicaragua, which was stopped by the lateness of the season during which he operated.

The next year, 1872–73, Capt. E. P. Lull, U. S. Navy, who had been Selfridge's assistant in the Darien expedition, completed the work of surveying the Nicaragua route with such success as to give, as he said, a "close approximation to the best line which was to be found." Captain Lull was followed in command by Lieut. F. W. Collins, U. S. Navy, who made further critical examinations, and a most exhaustive study was begun by nearly all the officers who had been engaged upon the field work. They were assisted by that indefatigable expert, Civil Engineer Menocal, U. S. Navy, whose name will ever be linked with that of Nicaragua. Captain Lull soon after went to Panama for the purpose of making a close instrumental examination in the vicinity of the Panama Railroad, where his expedition practically completed the series of explorations undertaken by the United States, which covered the whole Isthmus as far as it is applicable to ship-canal purposes; but by no means did this end the study of the field of possibilities, which has at last, by a process of elimination, culminated in the final plan to build the American canal at Panama, thus solving the world's greatest problem.

EXPLORATIONS IN CALIFORNIA

To another naval officer, Lieut. Edward Fitzgerald Beale, U. S. Navy, America is indebted for many important explorations in the Far West, which followed his services in the navy on the California coast. He was the first who brought to notice the discovery of gold in that then distant State, a discovery which resulted in the accumulation of vast wealth for his country and a great expansion of its domains. Beale became one of the first superintendents of Indian affairs in California.

HYDROGRAPHIC WORK IN THE ATLANTIC BY LIEUTENANT LEE

Until the advent of submarine cables gave rise to the necessity for an accurate knowledge of the bed of the ocean, no particular attention was paid to the subject; but that distinguished physical hydrographer, Commander Maury, U. S. Navy, early foresaw the need which might arise for this knowledge in dealing with the question of encircling the globe by wire, and he lent his commanding influence to the making of an examination of the bed of the ocean.

Such research work as was required could be carried on only under governmental control and by the scientific seamen whom the Government had in its employ. Hence in the fall of 1851 the U. S. brig *Dolphin*, under the command of Lieut. S. P. Lee, U. S. Navy, was commissioned for a cruise which had an important bearing upon the commerce of the world.

The charts of the North Atlantic Ocean showed a mass of representations of rocks and shoals which had accumulated for many years, many of them of doubtful character and position, and yet no Government seemed to feel the responsibility for making an investigation or expunging them from its charts. The work of investigating 56 of these doubtful dangers was assigned to Lee in the *Dolphin*, and he was at the same time to be employed "for testing new routes and perfecting the discoveries made by Lieutenant Maury in the course of his investigations of the winds and currents of the ocean," as authorized by an act of Congress dated March 3, 1849. The *Dolphin* returned to the United States in the summer of 1852, after an absence of eight months, and as a result of this voyage the navigation of the Atlantic was rendered safer and important contributions were made to physical geography, meteorology, and other sciences.

If I were to give the names of all naval officers who have since taken part in the study of oceanography it would be almost necessary to copy the United States Navy Register. But of Lieutenant Brooke, who was the inventor of a method for detaching heavy weights which

were dropped when the sounding line touched bottom; of Rear-Admiral Sigsbee, who invented the first real sounding machine, and of Capt. J. E. Pillsbury, who first solved the problem of anchoring ships in hundreds of fathoms of water and gave the first comprehensive study of deep ocean currents, mention must be made, though no amount of praise from me can add to their well-deserved world-wide reputation. This labor of investigating the bottom of the ocean has been so utilitarian in purpose that hardly a wire lies on the bed of the Atlantic or of the Pacific Ocean that has not been prearranged by the surveys of United States naval officers; and one of the glories of the United States Coast and Geodetic Survey, in which service until very recently naval officers have been employed as hydrographers, is that it has sounded minutely nearly 300,000 square miles of water and made deep-sea soundings over little less than a million square miles.

THE UNITED STATES NORTH PACIFIC EXPEDITION

An act of Congress dated August, 1852, appropriated a large sum of money for use "in prosecuting a survey and reconnoissance for naval and commercial purposes of such parts of Bering Strait, of the North Pacific Ocean, and the China Sea as are frequented by American whale ships and trading vessels in their routes between the United States and China."

The vessels of the expedition were the U. S. S. *Vincennes*, the steamer *John Hancock*, and the brig *Porpoise*, also the steamship *John P. Kennedy*, and the tender *Fenimore Cooper*.

The command of the expedition was first assigned to Commander Cadwallader Ringgold, an officer who had distinguished himself by his former participation in a work of like nature.

The squadron sailed from the United States in June, 1853, and proceeded to China by way of the Cape of Good Hope and the Indian Ocean, reaching Hongkong, China, March 16, 1854. The civil war then raging in China, which required the constant attention of the squadron, prevented much surveying work in the first year.

Ringgold having become incapacitated for duty, Lieut. John Rodgers, U. S. Navy, assumed command of the expedition and administered it to a successful ending. The details of the surveys made by Rodgers can not be dwelt upon here, but from the data collected there were made 15 charts of harbors and special localities and 20 charts of island groups and extensive coasts and seas, among which were charts of the Bonin Islands, the Liu-kiu group and the islands to the west, the mouth of the Pei-ho River, the Miao-tao Strait, the ports of Japan, the Tsugaru Straits and ports in Kam-

chatka, the Aleutian group, and the first American chart of Bering Sea.

In September, 1855, the brig *Porpoise* foundered with all hands on board during a terrific typhoon that swept the China Sea of many ships, and thus was lost to the expedition, the Navy, and the country, as the Secretary of the Navy stated, some of the most gallant and intelligent young officers that ever graced the service.

Captain Rodgers, with the *Vincennes*, after entering Bering Strait on July 16, 1855, proceeded northward for the purpose of verifying the position of land placed upon the charts by the report of Captain Kellet, of H. M. S. *Herald*, in about latitude 72° north, longitude 175° west, and also to examine, if possible, Plover Island, which had been reported as seen by that officer, and then to endeavor to reach Wrangell Land. Running for Wrangell Land, which at that time had never been seen by Europeans, he failed to discover it, although he went within 16 miles of its reported position. Curiously enough, it was the vessel named after him, the U. S. S. *Rodgers*, which twenty-six years later, under the command of Lieut. R. M. Berry, U. S. Navy, succeeded in reaching and charting this unknown land.

Having penetrated up to that time farther north in the Bering Sea route than anyone else, Rodgers's expedition returned to San Francisco and later made a cruise of exploration, searching for doubtful dangers in the Pacific Ocean west of that port. After making a survey of Hilo Bay, island of Hawaii, the *Vincennes* returned to New York by way of Cape Horn.

Besides gathering a vast amount of geographical data, sent to the Navy Department, Rodgers turned over to the Smithsonian Institution natural history specimens of considerable number and value so that, as predicted by the Secretary of the Navy, the labors of the officers and men of the expedition proved not only of great benefit to commerce, but also made interesting contributions to science.

COMMODORE PERRY'S EXPEDITION TO JAPAN

Probably no naval officer, and surely no United States naval officer, ever gained a greater triumph in foreign lands—a triumph whose benefits have enriched all nations and whose full fruition is inconceivable even at the present time, a half century after the expedition which brought it about entered upon its work—than Commodore Matthew C. Perry, whose expedition opened to the civilized nations of the world the Empire of Japan about the middle of the nineteenth century.

The expanding interests of the United States incident to the discovery of gold in California and the rapid settlement of that section of the country were just bringing into prominence the importance to us of the Pacific Ocean, when Perry, with great wisdom and fore-

thought, announced the opinion that "it is self-evident that the course of coming events will ere long make it necessary for the United States to extend its territorial jurisdiction beyond the limits of the Western Continent, and I assume the responsibility of urging the expediency of establishing a foothold in this quarter of the globe as a measure of positive necessity to the sustainment of our maritime rights in the East."

The Navy Department soon after fitted out an imposing fleet under the command of this distinguished officer, who sailed for China early in 1853. The main results of that expedition, which brought into the community of civilized nations that wonderful country which has long since passed out of leading strings and has not only become a world power, but a great world power, need not be dwelt upon here. My object is to give a brief statement of its scientific accomplishments, which have been so eclipsed by its greater achievements of commercial importance as hardly to be remembered at the present time.

During all the time that negotiations were going on for a treaty that should secure protection and kind treatment to all Americans who might through any cause find themselves within the jurisdiction of the Japanese people, as well as grant privileges never before conceded to them, Perry used his large force in making surveys and studying the then little-known countries which he visited. These included an extensive reconnaissance of Yeddo Bay to within a distance of 7 miles from the capital, and of the Liu Kiu Archipelago, where he established a port of refuge at Naka. While a part of the fleet waited at Naka to gain the confidence of the people of the group, which was a conquered dependency of Japan, Perry sailed to the Bonin Islands, and with two of his ships entered and established a harbor of refuge at Port Lloyd. He caused the principal islands to be explored and gave to the inhabitants varieties of garden seeds and some animals. He accumulated a large amount of geopraphical data, from which were made several charts of the Liu Kiu group of islands. Later the ship *Plymouth* was sent to the Bonin Islands to explore the interior of that group.

A monument recently established by the Japanese people at the place where Commodore Perry landed commemorates the important event which there took place, thus evincing the high esteem in which they hold this distinguished man who had reflected new honors on his country and its Navy.

SURVEYS IN JAPAN

Lieut. Murray S. Day, U. S. Navy, who was appointed as surveyor in chief in the Kaitakushi of Hokkaido, reported from Tokyo, Japan, under date of March 27, 1876, that the preliminary work in the trian-

gulation (Island of Yesso) has been extended over an area of about 12,000 square miles; that the survey of the coast line (as well as special surveys of the principal towns and villages of the coast) has been completed; that the accurate length of the Yubutsu base line has been determined by three measurements, and that the Hakodate base also has been prepared for accurate measurement; that the difference of longitude between Sapporo and Hakodate has been determined by the telegraphic method, and that a general map of the island has been constructed which shows the progress of the survey up to the close of the year, besides numerous sectional maps of coast lines, towns, and rivers, etc.

For a period of three years Day continued the work of organizing Japanese students into surveying parties and superintending, in the survey of the island of Yesso, all the field operations that underlie a scientific survey of large extent, including astronomy, triangulation, topography, and hydrography. It will be a source of congratulation to Americans to know that among the students that were trained by Day appear the names of some of the engineers upon whom Japan has relied in the past generation to take a leading part in carrying forward the magnificent geographical work that has now been accomplished in that Empire.

Thus it might be said that, in addition to the credit due the Navy of the United States for the work and the wise administration of Commodore Perry, from which so vast commercial and political advantages accrued to the civilized nations of the globe, an additional claim may be made in its behalf for the further development of Japan as a civilized nation resulting from Lieutenant Day's work.

In like manner, a sequel to the work of the United States North Pacific Surveying Expedition, the last chief of which was Commander John Rodgers, U. S. Navy, may be found on the surveys and explorations in China and Korea which took place under that officer while he was a rear-admiral in command of the United States fleet on the Asiatic Station in the years 1870–1873.

Rodgers, who, like his uncle, Commodore Perry, was a man of advanced ideas, was particularly interested in bringing into the civilized community of the world the then hermit nation of Korea. With the five vessels of his squadron he anchored off the Ferrières Islands, on the Korean coast, on the 19th of May, 1871, all hands full f high hope that at last this unknown country was to be opened to us, and through us to the people of the globe. But, though balked in his attempt to penetrate the fortified barrier surrounding Korea, Rodgers kept his officers and men busy in making surveys of such parts of the coast as could be reached, and the expedition brought back its share of glory and a considerable amount of data of a geo-

graphical character. Not only here, but in China also, did he keep his command occupied, and made several surveys in the Yangtze River and elsewhere.

OBSERVATIONS UPON THE KOREAN COASTS AND SIBERIA

It was left to a brother officer of Admiral Rodgers, the late Rear-Admiral R. S. Shufeldt, U. S. Navy, to accomplish what, but for the former's unfortunate conflict at arms with the Koreans, must have resulted in success, namely, to give to this hermit nation the blessings of civilization by inducing them to open their ports to the commerce of the world.

While many other nations besides the United States were enabled at the same time to make satisfactory treaties with the King of Korea, yet to Commodore Shufeldt, who, when in command of the U. S. S. *Swatara*, visited his capital and there took the initial steps toward swinging open the gates of the country to the world, credit must be awarded for beginning this work.

Immediately after Commodore Shufeldt had completed the treaty negotiations with the Korean Government at Inchon, on the west coast of Korea, three young officers—Lieut. B. H. Buckingham and Ensigns George C. Foulk and Walter McLean—proceeded from Japan to the United States via Korea and Siberia for the purpose of studying the countries passed through. Their report is made up of over 160 pages of printed matter, and is full of geographical and other information, which at that time was greatly needed.

ARCTIC DISCOVERERS

The attempt to discover the Northwest Passage—the great geographical problem of the age in the early half of the nineteenth century—having allured many an intrepid voyager to destruction, finally reached a climax in the reported loss of Sir John Franklin's expedition to the polar seas in 1847. This event cast a gloom over the British Isles and produced in this country the most profound sympathy and a determination to use all practical means to relieve the surviving members of the expedition. For the purpose of searching for the lost party, Henry Grinnell, esq., of New York, offered to fit out two ships. The Government of the United States gave the scheme cordial support, assumed the responsibility of equipping the vessels, and made the expedition national in character. Volunteers from the United States Navy were called to man the ships, and among the first to answer were Lieut. Edward J. De Haven and Passed Midshipman Samuel P. Griffin. The former was placed in command of the expedition in the *Advance*, a brigantine of 144 tons, and the latter became his assistant in command of the brigantine *Rescue*

The chief object of the expedition was the search for Sir John Franklin, but De Haven was directed by the Secretary of the Navy "to pay all due attention to subjects of scientific inquiry."

The Secretary of the Navy, in his report of November 29, 1851, said:

> The expedition under Lieutenant Commanding De Haven to the arctic seas in search of the British commander Sir John Franklin and his companions returned to the port of New York in October, having discovered only supposed traces of the objects of which it was in quest, and leaving in entire uncertainty their actual fate. * * * Though failing in the main object of the search, Lieutenant De Haven and his officers verified by their explorations many facts before unknown to science but indicated in the course of investigation carried on at the Naval Observatory.

From his data Grinnell Land was added to our charts.

The journal of Passed Asst. Surg. E. K. Kane, U. S. Navy, the surgeon of the expedition, is replete in notices of natural features of the Arctic Zone which have now become history, and so well did he do his share of the scientific investigations of the expedition, in addition to his duty of caring for the sick, that he was selected to command the second search party.

This second party of 17 persons, in the same brigantine, *Advance*, which had been a home for some of them in the De Haven expedition, again crossed the Arctic Circle, and for two years and more made history for themselves and an honorable record for the Navy. Time does not permit an account of it more than to note that it was unsuccessful in the main object of the search and was so overwhelmed by insurmountable difficulties as to require another search party in its own behalf. This was also a naval expedition, under command of Capt. Henry J. Hartstene, U. S. Navy, comprising the purchased bark *Release* and the steamer *Arctic*, with 40 officers and men for a crew. It brought back to the United States 15 members of the Kane party and his vast store of geographical and scientific data, which but for the relief party might never have been found.

In 1870 Charles Francis Hall was directed to organize an Arctic polar expedition under the supervision of the Navy Department, and the U. S. S. *Polaris* was selected as a home for the force to be employed under his command. The expedition passed through the waters between Greenland and British America as far as latitude 82° 16′ north, a point much nearer the North Pole than had ever been attained up to that period. More than 700 miles of coast line were discovered or recharted, and it then became known that Kennedys Channel opened into another body of water, to which Hall gave the name of Robeson Channel, in honor of the Secretary of the Navy. Land was also discovered extending as far north as the eighty-fourth

degree of latitude. Captain Hall died at Polaris Bay in 1871, and the expedition was shipwrecked and so delayed in returning to the United States that the Navy Department sent out a relief expedition, composed of the U. S. S. *Juniata*, Commander D. L. Braine; the U. S. S. *Tigress*, Commander James A. Greer; and the steam launch *Little Juniata*, which belonged to Braine's ship and was placed by that officer under command of Lieut. G. W. De Long. This force obtained results which still further added to the fruits of the original expedition, the records of which were saved.

De Long in this search work acquired such a taste for exploration that he did not rest until he had obtained the command of a ship, which was donated by Mr. James Gordon Bennett, of New York. The *Jeannette* was fitted out by the Navy Department, under the authority of an act of Congress, for the purposes of north polar exploration. Being impressed that the chances of success were greater by the Bering Sea route, De Long, proceeded through Bering Strait, and passed northwestward, with the object of reaching the North Pole.

The sad fate of this expedition is of too recent date to require a story here. De Long discovered Jeannette, Henrietta, and Bennett islands, and they are charted and stand as monuments to the bravery, fortitude, and intelligence of this daring explorer. One little episode of the expedition—that of two of his party who were sent in search for food for their dying companions returning with one little bird they had shot, to divide up between 18 stricken men—shows the wonderful control De Long, Chipp, Danenhower, Melville, and Ambler had over their men.

The country went into sincere mourning over the death of almost the entire party, but "their works shall live after them," and the story of their heroism is left us as a precious heritage.

In June, 1881, Lieut. R. M. Berry, U. S. Navy, was sent with the U. S. S. *Rodgers* to search for De Long's missing party, and in a fruitless attempt to penetrate the ice pack which had closed over the ill-fated *Jeannette* the officers of the *Rodgers* first surveyed Herald Island and afterwards circumnavigated and charted Wrangell Island, proving conclusively that it was not a part of the Asiatic coast, as had been supposed by some geographers. With a view of affording every possible relief to the *Jeannette* expedition, the U. S. S. *Alliance*, Commander George H. Wadleigh, was also sent in search of De Long. Wadleigh brought back a large amount of geographical data, as well as specimens relating to different sciences. Unfortunately, Berry's vessel was destroyed by fire in the frozen regions, but his party was saved. Still in pursuit of information concerning the *Jeannette*, Berry traveled afoot across northern Siberia from Bering Strait to

the mouth of the Lena Delta and returned to the United States, and by his trip contributed to the geographical treasury no small amount of information.

With our distinguished president of the Congress, Commander Peary, soon to tell his story, it would be presumptuous in me to make reference to what he, another naval officer in whom we all take great pride, has done for geography and science in general. Your votes, which have called him to this high office, show that his reputation belongs to the world as well as to the United States Navy.

DES CHRÉTIENS DE SAINT MATHIEU EXISTANT EN AFRIQUE AU COMMENCEMENT DU QUATORZIÉME SIÉCLE, ET DE L'IDENTIFICATION À L'OUGANDA DE L'EMPIRE CHRÉTIEN DE MAGDASOR

Par F. ROMANET DU CAILLAUD, Haute Vienne, France

En 1307, raconte le bienheureux Odorico de Pordenone, dans sa chronique, citée par Wadding,[a] Frère Jean de Montecorvino, le premier missionnaire franciscain en Chine, qui fut archevêque de Khan-Baligh ou Pékin, reçut des ambassadeurs (solemnes nuntii), qui venaient d'une certaine partie de l'Éthiopie. Ils le prièrent de venir prêcher chez eux ou d'envoyer dans leur pays des missionaires; parce que, disaient-ils, depuis le temps de Saint Mathieu et de ses disciples, ils n'avaient plus de ministres de la foi du Christ. Que si des missionnaires venaient chez eux, tous se convertiraient et deviendraient de vrais chrétiens; car dans leur pays il y en avait beaucoup qui n'étaient chrétiens que de nom, croyant à Jésus-Christ et vivant simplement, mais ne sachant rien des écritures et des saintes doctrines.

Frère Jean de Montecorvino était alors seul à Pékin et ne suffisait pas au travail que lui donnait son nombreux troupeau apostolique. Il ne put donc faire autre chose que transmettre à ses supérieurs d'Europe le désir qu'avaient ces éthiopiens de recevoir des missionnaires.

I

A quelle partie de l'Afrique appartenaient les éthiopiens qui envoyèrent cette ambassade à Frère Jean de Montecorvino?

Ils n'appartenaient point à l'Abyssinie. L'Abyssinie ou Haute-Éthiopie n'a pas été convertie par Saint-Mathieu au premier siècle mais par Saint-Frumentius au quatriéme siècle. En outre au quatorzième siécle, elle était, de même qu'aujourd'hui, en rapports religieux avec le patriarche jacobite d'Alexandrie.

Ils n'appartenaient pas non plus à la Nubie ou Basse-Éthiopie. A la vérité, la Basse-Éthiopie a été le lieu principal de la prédication de

[a] Wadding, Annales minorum, année 1307, No. VI, citant l'ouvrage du bienheureux Odorico de Pordenone, intitulé Chronica compendiosa a mundi exordio usque ad finem ferme Pontificatus Joannis XXII.

Saint-Mathieu; mais après sa mort, la foi en disparut, probablement par suite de l'invasion des Nubiens idolâtres; et au sixième siècle le pays dut être de nouveau converti au christianisme par deux missionnaires jacobites Julianus et Longinus[a]; dès lors il dépendit du patriarcat jacobite d'Alexandrie. On est certain qu'à la fin du treizième siècle il y avait encore en Nubie des evêques qui dépendaient de ce patriarcat.[b]

Quels étaient donc ces chrétiens éthiopiens, dont les ancêtres avaient été jadis convertis par Saint Mathieu, et qui, bien que chez eux le sacerdoce se fût éteint dès les premières générations qui suivirent la mort de l'apôtre, avaient encore la foi chrétienne au commencement du quatorzième siècle?

Au quatorzième siècle, d'après un Franciscain castillan qui traversa l'Afrique de l'ouest à l'est[c], il y avait en Afrique trois états chrétiens: l'empire d'Abdeselib, c'est-à-dire du serviteur de la croix (c'est l'Éthiopie abyssine), le royaume de Nubie, et l'empire de Magdasor.

Si l'authenticité de ce voyage est contestée, on ne peut néanmoins contester que ce récit ne soit une compilation des connaissances géographiques de l'époque; d'autant plus qu'il reproduit les indications d'un portulan, dont, pour cenx qui doutent de son authenticité, il serait le copie mise en narration de voyage.

Ce dernier était un grand empire, contenant beaucoup de villes, de villages et de châteaux. Son étendard était blanc avec une croix noire à deux branches. En sortant de cet empire, on parvenait aux bords de l'Océan Indien, dans les environs de l'île de Zinzibar (Zanzibar).

Malgré la similitude des noms, il ne faudrait pas identifier l'état chrétien de Magdasor avec la ville de Magadoxo (Makdishu des Arabes) de la côte du Zanguebar; car au quatorzième siècle cette ville avait un prince musulman.[d] Même elle avait été fondée par des musulmans chiïtes, appelés Emozaïdes, parce qu'ils étaient partisans de Zaïd, petit-fils de Hocein, fils d'Ali, le gendre de Mahomet.[e]

Mais si au quatorzième siècle la côte du Zanguebar était soumise á l'Islam, á l'intérieur il pouvait y avoir un état chrétien, s'étendant jusqu'aux Grands Lacs et jusq'au Nil supérieur, état qui eût répondu à l'empire chrétien de Magdasor, dont parle le Franciscain castillan. Actuellement, en effet, la croix est employée comme ornement traditionnel parmi deux tribus du Zanguebar septentrional, les Wa-Nyika et les Wa-Boni; ces derniers, notamment, dispersés par

[a] Land, J. P. N., Joannes Bischof von Ephesos, Leyde, 1856, pp. 185–193; Smith, Payne, Traduction anglaise de l'Histoire ecclésiastique de Jean, évêque d'Ephèse, Oxford, 1860, pp. 251–256, 316–321.

[b] Quatremère, Et., Mémoires géographiques et historiques sur l'Égypte et sur quelques contrées voisines. Paris, 1811, tome 11, p. 107.

[c] Libro del conoscimiento de todos los reynos y tierras y señorios que son por el mundo y de la señales y armas que han cada tierra y señorio, por sy y de los reyes y señores que los proueen, escrito por un Franciscano Español á mediados del siglo XIV, publié par M. Marcos Jiménez de la Espada, Madrid, 1877, pp. 63 69.

[d] Voyages d'Ibn-Batoutah, Traduction de C. Defrémery et R. Sanguinetti, Paris, 1877, tome 11, pp. 180–181.

[e] João de Barros, A Asia, decada I, liv. VIII, c. 1.

petits groupes dans le bassin du Tana, ont des croyances monothéistes.[a] Plus loin, à l'intérieur, vers le cinquième degré de latitude nord, le comte Teleki a rencontré une tribu chrétienne.[b]

L'empire chrétien de Magdasor, communiquant avec la côte du Zanguebar, devait profiter des relations du Zanguebar avec les pays étrangers.

Or, il y a eu des relations entre la Chine et la côte de Zanguebar au moins dès le treizième siècle. Des sapèques chinoises ont été trouvées à Magadoxo et à Monfia; une faïence chinoise céladon est incrustée dans le mur d'une mosquée de Magadoxo datant de 1269; d'autres faïences chinoises ont été vues parmi les ruines de la baie de Mtangata. Ces faïences chinoises portent encore au Zanguebar le nom de Zeïtoun, c'est-à-dire le nom arabe du port chinois le plus florissant au moyen-âge.[c]

D'autre part, il est certain que, au commencement du siècle suivant, en 1420, trois navires chinois, portant une ambassade chinoise au sultan de l'Yémen, vinrent au port d'Aden, c'est-à-dire au port de l'Asie occidentale le plus proche du Zanguebar.[d]

Au quatorzième siècle, d'après Ibn-Batoutah,[e] la garde militaire des navires, qui commerçaient entre la Chine et l'Inde, était en grande partie composée d'abyssins. Il est probable que cette garde soi-disant abyssine comprenait, non seulement des guerriers originaires du golfe de Tadjourah et du versant occidental de la Mer Rouge, mais encore des guerriers d'un armement similaire venus des côtes du Somâl et du Zanguebar.

Ainsi, il est possible qu'au quatorzième siècle les chrétiens de l'empire de Magdasor aient eu par le Zanguebar des relations avec la Chine. Et, supposé que par ces relations ils eussent appris l'arrivée à Pékin d'un missionnaire chrétien, ils auraient du songer à l'attirer dans leur pays.

Il est donc à croire que les chrétiens de Saint-Mathieu, qui envoyèrent des ambassadeurs à Frère Jean de Montecorvino à Pékin, étaient de l'empire de Magdasor.

II

Quelle est l'origine du christianisme dans l'empire de Magdasor, ou plutôt comment l'état qui envoya des ambassadeurs à Frère Jean de Montecorvino avait-il reçu de Saint Mathieu la foi chrétienne?

Ici deux hypothèses se présentent: ou cet état existait au temps de Saint-Mathieu et a été converti par lui, ou il a été fondé plus tard par des descendants des Africains convertis par Saint-Mathieu.

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[a] Missions catholiques, année 1890, pp. 583–586.

[b] Annales apostoliques de la Congrégation du Saint-Esprit et du Saint-Cœur de Marie, avril 1889.

[c] Revoil, Voyage chez les Benadirs, etc., Tour du monde, 1885, p. 196, col. 1; R. P. Le Roy, De Zanzibar à Lamo, Missions catholiques, 1889, p. 13.

[d] Johannsen, Historia Iemanæ, e codice manuscripto arabico . . . concinnata, Bonn, 1828, p. 174.

[e] Op. cit., t. IV, p. 3.

1°. Dans le premier cas, ce serait le royaume de Myrména, peuplé d'anthropophages au temps de Saint-Mathieu et dont le roi Fulvianus, d'après l'historien ecclésiastique Nicéphore Callixte,[a] aurait fait mourir Saint-Mathieu, puis, s'étant converti, aurait plus tard succédé, comme évêque de Myrména, à Platon, le disciple de Saint-Mathieu. Cet état de Myrména était sur le bord d'une mer, et cette mer était peut-être un des grande lacs de l'Afrique centrale, le Victoria-Nyanza, par exemple.

2°. La seconde hypothèse serait plus plausible; elle est conforme au texte du Franciscain castillan, d'après lequel l'empire de Magdasor aurait été "peuplé de chrétiens de Nubie."[b]

Comment se serait formé cet état?

Le royaume de la Basse-Éthiopie, colonie égyptienne dont Napata était la capitale,[c] passe pour avoir été le principal théâtre de la prédication de Saint-Mathieu et le lieu de son martyre.[d] Une bonne partie de la population reçut la foi chrétienne, grâce à l'eunuque de la reine Candace, qui avait été baptisé en Palestine par le diacre Saint-Philippe, et qui accueillit Saint-Mathieu à son arrivée en Basse-Ethiopie. Saint-Mathieu convertit même une princesse de sang royal, Sainte-Ephigénie; et, s'il fut martyrisé par le roi de Basse-Éthiopie, ce fut moins à cause de la foi qu'il prêchait que parce qu'il ne voulut pas autoriser le mariage avec le roi, son oncle, de Sainte-Ephigénie, qui avait fait vœu de virginité.

Cependant, quel qu'ait été le succès de la prédication de Saint-Mathieu dans la Basse-Éthiopie, l'eglise qu'il y avait fondée disparut complètement; et cela malgré la proximité de l'Égypte, où le christianisme était si florissant.

Au temps de Saint-Mathieu il y avait, à l'ouest du royaume de Basse-Ethiopie, un peuple indépendant de ce royaume,[e] le peuple Nouba ou Nubien, qui adorait Isis et Osiris[f] et resta païen jusqu'au sixième siècle, époque à laquelle il fut converti par des missionnaires monophysites.[g] Ce peuple conquit le royaume de Basse-Éthiopie et lui imposa même son nom, le nom de Nubie.

C'est probablement devant cette conquête païenne que disparut la chrétienté basse-éthiopienne fondeé par Saint-Mathieu. Mais, en s'appuyant sur le texte du Franciscain castillan, on peut supposer

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[a] Hist. eccl., Lib. II, Cap. XLI.

[b] Op. cit., p. 67 . . . Tierra muy poblada de Xpianos de nubia.

[c] Maspero, G., Histoire ancienne des peuples de l'Orient, Paris, 1878, passim, voir la table.—Cf. Strabon, L., XVII, édition d'Oxford, 1817, p. 1161, lignes 13-14.

[d] D'après l'Historia certaminis apostolici (Paris, 1566, pp. 85-97), faussement attribuée à Abdias, premier évêque de Babylonie; histoire qui, bien qu'apocryphe quant à son auteur, est considérée comme la plus véridique en ce qui concerne la prédication de Saint-Mathieu, puisqu'elle est suivie par le bréviaire romain.

[e] Strabon, L., XVII, édition d'Oxford, 1817, p. 1117, lignes 3-7.

[f] D'après Priscus et Procope, cités par Letronne, l'Inscription grecque du temple de Talmis, pp. 162, 163 (Mémoire à l'Académie des inscriptions et belles-lettres de Paris).

[g] Jean d'Ephèse, loc. cit.

qu'une partie de ces chrétiens bas-éthiopiens émigra vers le haut Nil et y fonda quelques colonies chrétiennes. C'est d'une de ces colonies que serait sorti l'empire chrétien de Magdasor.

III

A quel état de l'Afrique orientale peut-on identifier l'empire chrétien de Magdasor?

L'empire de Magdasor, dit le Franciscain castillan, était entouré de deux fleuves issus des grandes mers qui environnent le paradis terrestre;[a] le bruit des cataractes de ces fleuves était assourdissant.[b]

En sortant de cet empire, le Franciscain castillan se dirige vers le Levant; il suit un bras du fleuve Gion, et, "à travers des nations de croyances et coutumes diverses," il parvient à la mer des Indes entre Aden et Zanzibar.[c]

L'état qui me paraît le mieux répondre à l'empire chrétien de Magdasor serait un état dont le noyau aurait été le royaume actuel d'Ouganda.[d]

Aux grandes mers dont il est question plus haut correspondraient les grands lacs d'où sort le Nil; aux deux fleuves issus de ces mers, le Nil qui sort du Victoria-Nyanza et le Nil qui sort du Moutav-Nzighé.

Comme rien n'indique que le Franciscain castillan ait mathématiquement suivi leur cours, il est possible qu'il ait cru retrouver l'un d'eux dans le fleuve qu'il côtoya pour se rendre à l'Océan Indien.

Enfin, les cataractes assourdissantes fournies par les eaux de ces fleuves seraient les chutes Ripon et Murchison.

Du nom de l'Ouganda on peut grammaticalement déduire le nom de Magdasor.

L'empire de Magdasor tirait son nom de celui de sa capitale, laquelle était également appelée Magdasor.[e] Il est probable que Magdasor n'était pas le nom indigène de cette ville, mais celui que lui donnaient les étrangers. Or, c'est du persan que sont dérivées les terminaisons de plusieurs noms géographiques de l'Afrique orientale, notamment de ceux de Zanguebar et de Zanzibar.[f]

La syllabe "sor," qui termine le nom de Magdasor, me semble être la contraction du mot persan "schahar," lequel veut dire ville.[g] Magdasor signifierait donc la ville des Magda, comme Zanguebar signifie le pays des Zends.

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[a] Op. cit., p. 67 . . . todo cercado de los dos rios que salen de los grandes piélagos que se fazen derredor del paraiso terrenal.

[b] Op. cit., p. 65.

[c] Op. cit., pp. 68–69.

[d] Grammaticalement il faut écrire Buganda, *u* se prononçant *ou*; mais j'emploie le nom plus connu d'Ouganda, lequel est, pour ainsi dire, acclimaté en français. Dans ces mots l'*n* se prononce absolument, comme si on avait écrit Ougannda, etc.

[e] Op. cit., p. 67 . . . Vna grand çibdat que dizen Magdasor . . .

[f] D'Herbelot, Bibliothèque orientale, Maëstricht, 1776, article Bar.

[g] Id., ibid., articles Schahar et Scheher.

Quant au nom de Magda, il me paraît être dérivé de celui d'Ouganda. En Ruganda (langue de l'Ouganda), comme dans les langues Bantu similaires, les modifications d'un substantif se font, non point par la terminaison, mais par le prétixe: grammaticalement on dit "Mganda" pour un habitant de l'Ouganda, "Baganda" pour des habitants de l'Ouganda.[a]

Mais les étrangers ne s'astreignent pas aux règles grammaticales des langues qu'ils ignorent. Et, de même qu'actuellement, dans la région du cap de Bonne-Espérance, les européens et les descendants d'européens disent un Basuto, au lieu de dire un Masuto;[b] de même, que les missionnaires de l'Ouganda eux-mêmes, quoique sachant le ruganda, écrivant en français disent des lubalés, au lieu de dire des balubalé;[c] de même il est probable qu'au quatorzième siècle les étrangers qui fréquentaient l'Afrique orientale, disaient les Mganda au lieu de dire les Baganda; car nous voyons deux siècles plus tard les Portugais dire les Muzimbas, au lieu de les Bazimba,[d] et dire indiffércmment Benomotapa et Monomotapa, le nom de Monomotapa, c'est-à-dire le nom de l'habitant au singulier, ayant fini par l'emporter.[e]

Le mot Mganda n'est pas facile à prononcer. Par une interversion analogue à celle qui a fait traduire le nom latin Vogesus par le nom français Vosges, ce mot se serait d'abord transformé en Mangda, puis, par l'élision de l'n, en Magda.

Mganda-Schahar serait ainsi devenu Magda-sor, et ce nom composé signifierait "la ville des habitants de l'Ouganda."

Le voyaume d'Ouganda est le plus ancien de l'Afrique orientale; il remonte au moins au douzième siècle. Il semble avoir été chrétien à l'origine.

Ainsi qu'on peut le déduire des légendes, son fondateur Kintu était étranger au pays; il épousa une princesse aborigène.

C'est la seule femme qu'il eut. Cet état monogamique de Kintu, au milieu de la corruption polygamique de l'Afrique, donne lieu de supposer qu'il était chrétien.

Cette opinion est confirmée par ce fait que ses descendants observaient le dimanche comme jour férié. Pour eux le dimanche était consacré au repos, et ce jour-là ils mettaient leurs plus beaux nbugo[f] (étoffes d'écorce d'arbre) et préparaient avec plus de soin leurs repas.

La doctrine de Kintu a été plus particulièrement conservée dans le district où se trouve le temple élevé en son honneur. Lorsque les habitants de ce district entendirent parler de la doctrine chrétienne, ils furient frappés de sa ressemblance avec celle de Kintu: "Mais c'est

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[a] Voir Mgr. Livinhac, Essai de grammaire ruganda, Paris, imprimerie F. Levé, 1885.

[b] Cf. L. Dècle, Séance de la Société de géographie de Paris du 18 mars 1892, p. 139.

[c] Missions d'Afrique (Alger), Bulletin de 1888, pp. 251, 360—Lubaré=une divinité, balubalé=des divinités.

[d] Diogo de Couto, continuateur de João de Barros, A Asia, decada XI, édition de Lisbonne, 1788, p. 80.

[e] João de Barros A Asia, decada I, liv. X, cap. 1; Diogo de Couto, A Asia, decada IX, cap. XX.

[f] Pluriel de lubugo.

comme nous," s'écrièrent-ils, "les missionnaires enseignent comme Kintu enseignait. Ils enseignent qu'il ne faut pas tuer; lui aussi ne voulait pas qu'on tuât."

Au moment de l'arrivée des missionnaires, la vénération des habitants de l'Ouganda pour la mémoire de Kintu était telle que sa doctrine était respectée dans les honneurs qu'on lui rendait. Le culte qu'on avait pour lui n'était pas idolatrique; on ne lui offrait pas de sacrifices; on n'allait pas lui demander des oracles, comme aux Balubalé[a] (divinités païennes de l'Ouganda).[b]

Au reste, le culte des Balubalé n'existait point en Ouganda au temps de Kintu; c'est le onzième successeur ce prince qui l'a introduit dans le pays.

Irrité des crimes qui se commettaient dans son royaume, Kintu le quitta furtivement; et jamais on n'a su ce qu'il était devenu. Son tombeau ne se retrouve nulle part en Ouganda, alors que ceux de tous ses successeurs sont réligieusement gardés. Longtemps après sa disparition, il apparut à un de ses successeurs dans une forêt; et c'est à cet endroit que fut élevé le temple qui lui est dédié.

Il semble donc probable que le fondateur du royamue d'Ouganda ait été chrétien et que, à son exemple les habitants de l'Ouganda aient, dans le principe, professé le christianisme.

Parmi les coutumes des païens de ce pays, il en est une qui paraît avoir une origine absolument chrétienne; c'est la cérémonie par laquelle le père donne à son enfant le nom qu'il devra porter: après avoir indiqué ce nom aux parents invités, il verse de l'eau sur la tête de l'enfant. Ne faut-il pas voir dans cette "coutume" une réminiscence du baptême chrétien?[c]

Les habitants de l'Ouganda se disent originaires du nord. Il est certain qu'une grande partie des populations du bassin des Grands-Lacs vient du nord. Sur la rive sud-occidentale du Victoria-Nyanza, chez les Basiba, se trouve le bœuf de race européenne, le bœuf sans bosse, alors que presque par toute l'Afrique nègre il n'y a que des bœufs à bosse.[d] Plus au nord, du côté du lac Mouta-Nzighe, sur le mont Gordon Bennett, vivent les Gambarraga, peuple dont les individus de race pure ont la peau blanche.[e]

Stanley raconte que les traits de Mtéza, le roi d'Ouganda qui régnait lors de son passage en 1875, lui rappelèrent ceux des colosses de Thèbes et des statues du musée du Caire.[f] Or, les rois de la Basse-Ethiopie, où Saint-Mathieu prêcha l'évangile, étaient de la famille

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[a] Pluriel de Lubaré.

[b] Denoît, C., Bulletin des Missions d'Afrique (Alger), 1888, p. 360.

[c] Bulletin des missions d'Afrique (Alger), mai-juin 1892, pp. 375–376.

[d] L'exploration du P. Schynse dans le sud-ouest du Victoria-Nyanza, Nouvelles géographiques, Paris, 1891, p. 325.

[e] Stanley, A travers le Continent mystérieux, Traduction française, Tour du monde (de Paris), 1878, tome II, p. 68.

[f] Id., ibid., p. 34, col. 1.

des prêtres-rois d'Ammon-Râ de Thebes[a], et la population du pays était un mélange d'Egyptiens et de Koushites.[b]

D'après certains voyageurs, le type des habitants de l'Ouganda est assez semblable à celui du Bedjah du désert nubien d'entre Nil et mer Rouge[c]. Les Bedjah descendent des Blemmyes[d], lesquels, au dire de Strabon[e], faisaient partie du royaume de Basse-Ethiopie et étaient probablement, comme les bas-ethiopiens, des Koushites plus ou moins métissés d'Egyptiens. Ce nom de Bedjah se retrouve dans la langue de l'Ouganda; il sert à désigner les princesses de sang royal. On dit Mubeja, une princesse; Bambeja, des princesses.

Dans la Basse-Éthiopie, du moins au temps du paganisme, la royauté était élective parmi les princes du sang; et le roi demeurait sous la domination du conseil qui l'avait élu.[f] En Ouganda, le roi était aussi élu parmi les fils du souverain décédé; et il ne pouvait, à son gré, abdiquer le pouvoir. Cette dernière particularité résulte spécialement de la légende du roi Daura.[g]

Enfin, en Ouganda existait une coutume que nous retrouvons dans la Haute-Éthiopie chrétienne, et qui peut-être lui était commune avec la Basse-Éthiopie. En Ouganda, les fils du roi régnant étaient enfermés dans une enceinte sous la garde d'un chef. En Haute-Éthiopie cette coutume a été longtemps en vigueur.[h]

IV

Je résume ainsi mon hypothèse:

Le royaume de Basse-Éthiopie, qui avait été en partie converti au christianisme par Saint-Mathieu, ayant été dans les siècles suivants envahi par les Nubiens idolâtres, un certain nombre de chrétiens bas-éthiopiens auraient émigré dans la région du haut Nil.

D'une de ces colonies de Bas-Éthiopiens chrétiens serait, au douzième siècle, sorti Kintu, le fondateur du royaume d'Ouganda, royaume qui aurait été chrétien à son origine, mais chrétien sans prêtres.

Ce royaume serait le même que l'empire chrétien de Magdasor du quatorzième siècle.

Au commencement du quatorzième siècle, comme cet état, de même que le reste de l'Afrique orientale équatoriale, était en relations

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[a] Maspero, op. cit., p. 382.

[b] Id., ibid., passim.

[c] Bulletin des Missions d'Afrique (Alger), 1892, p. 277.

[d] Et. Quatremère, Mémoire sur les Blemmyes, tome II, des Mémoires sur l'Égypte et sur quelques contrées voisines, Paris, 1811, pp. 127-161.

[e] Liv. XVII, édition citée, p. 1116.

[f] Maspero, *op. cit.*, p. 534.

[g] Voir cette légende, pp. 83-87, de la *Grammaire Ruganda* de Mgr. Livinhac.

[h] En Haute-Ethiopie, les lieux de détention des princes du sang s'appelaient Amara d'après Ortelius; Gesher et Ambasel d'après Ludolf; Dher d'après Combes et Tamisier.

avec la Chine, les chrétiens qui l'habitaient ayant appris l'arrivée à Khanbaligh (Pékin) du Franciscain Jean de Montecorvino, lui auraient adressé des ambassadeurs pour lui demander de venir lui-même leur enseigner la religion chrétienne ou au moins de leur envoyer des missionnaires.

Sans doute ce désir ne put être exaucé, et la foi déclinant de plus en plus dans le pays, moins d'un siècle plus tard le onzième successeur de Kintu introduisit le culte idolatrique des Balubalé.

Telle est mon hypothèse.

Je souhaite que des recherches ultérieures la confirment pleinement, et qu'il soit démontré que la vaillante race de l'Ouganda, qui, la première de l'Afrique au dix-neuvième siècle, a fourni des martyrs à la religion chrétienne, descend des éthiopiens convertis au premier siècle par l'apôtre Saint-Mathieu.

LES LIMITES AU NORD-OUEST DE LA LOUISIANE CÉDÉE PAR LA FRANCE AUX ÉTATS-UNIS EN 1803

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[Note adressée à la Société de géographie de Paris.]

Sur le timbre-poste qu'ils ont émis pour le centenaire de l'acquisition de la colonie française de la Louisiane, les États-Unis ont donné à cette colonie les Montagnes Rocheuses comme limite.

Je crois que cette délimitation n'est pas exacte et qu'il faut comprendre dans la Louisiane vendue en 1803 par la France, la partie des États-Unis située à l'ouest des Montagnes Rocheuses et au nord du quarante-deuxième degré de latitude, c'est-à-dire les États d'Idaho, d'Orégon et de Washington.

Lorsque, à la paix de Paris de 1763, la France céda la Louisiane à l'Espagne, les limites de cette colonie du côté du nord-ouest étaient indéterminées. En effet, dans le Dictionnaire géographique de Bruzen Lamartinière, géographe du roi d'Espagne (tome V, La Haye, 1735, à l'article Louisiane, p. 322, col. 1, lignes 64–67), on lit: "Du côté du nord-ouest et de l'ouest étant au nord du Mexique, les limites ne sont pas non plus connues."

Si vers 1786 l'Espagne fit acte de souveraineté jusqu'au détroit de San Juan de Fuca, lorsque par son commandant de marine Quadra elle remit au commodore anglais Vancouver l'île qui s'appelle du nom de ce dernier, c'est qu'à cette époque elle était encore souveraine de la Louisiane.

En 1795, au traité de Bâle, l'Espagne rendit la Louisiane à la France, et en 1803 Napoléon vendit cette colonie aux États-Unis.

Bien longtemps avant la guerre qu'en 1846 ils firent au Mexique et qui leur a donné le Nouveau-Mexique et les Etats du Pacifique situés au sud du quarante-deuxième degré de latitude, les Etats-Unis administraient les territoires du bassin du Pacifique sis au nord dudit quarante-deuxième degré de latitude, en donnant à ces territoires le nom de district d'Orégon ou de Columbia. C'est ce qu'on peut voir dans l'atlas de Delamarche de 1828–1830 et dans celui de Lapie de 1842.

Même ce district d'Orégon ou de Columbia comprenait la partie de la Colombie britannique cédée à l'Angleterre en 1846, qui était située entre la frontière actuelle et la rive gauche du Fraser.

La souveraineté des Etats-Unis sur ce district d'Orégon ou de Columbia a dû être reconnue par l'Espagne, soit au traité de Washington de 1819 qui admit la souveraineté de l'Espagne sur le Texas, soit au traité de 1821 par lequel l'Espagne vendit la Floride aux Etats-Unis.

Mais, avant leur traité avec le Mexique qui suivit la guerre de 1846, les Etats-Unis ne pouvaient avoir de droit sur quelque partie que ce fût de la côte du Pacifique que comme cessionnaires de la Louisiane française.

C'est donc à tort que le timbre-poste du centenaire de la Louisiane ne comprend pas, dans les limites du sol acquis par les Etats-Unis en 1803, les Etats d'Idaho, d'Orégon et de Washington.

LES PROVINCES ÉQUATORIALES D'ÉGYPTE

Col. CH. CHAILLE-LONG

L'extension du domaine d'Égypte de la mer Méditerranée aux sources du Nil aux Montagnes de la Lune légendaires a été l'ambition de chacun des conquérants de l'Égypte, depuis Mènes jusqu'à Mohammed-Aly, et jusqu'a Ismaïl Khédive qui a achevé ce rêve.

Maspéro, dans son Histoire ancienne des peuples de l'Orient, maintient que les anciens Égyptiens possédaient une connaissance complète des sources du Nil et qu'entre le dix-septième et le quatorzième siècle avant Jésus-Christ l'Éthiopie, ou le pays de Koush, fut province égyptienne administrée par les princes égyptiens. D'ailleurs, il y avait eu conquête et occupation réelle des contrées du Nil supérieur sous la monarchie égyptienne de la douzième dynastie par les rois Ousertens et Amenemhat.

Il est bon de rétablir ce fait historique; il empêche les prétendus historiens de taxer de folles entreprises les efforts légitimes et louables des vice-rois d'Égypte de reculer les frontières du pays jusqu'aux Grands Lacs, ses anciennes limites.

L'expédition française inaugura en Égypte une ère de progrès et de civilisation. Le premier acte de Bonaparte, qui eut été un savant s'il n'avait été un guerrier, fut la création de l'Institut d'Égypte (qui est aujourd'hui l'Institut égyptien), lequel créa la célèbre commission chargée des études scientifiques du pays. Mohammed-Aly s'inspirant de cette tentative française se livra à la conquête et à l'exploration des régions nilotiques.

Mohammed-Aly à la suite des guerres contre les Wahabites en 1811 entreprit la conquète de la Nubie et du Sennaar et fonda en 1820 au confluent du Bahr-el-Abiad et du Bahr-el-Azrak la ville de Khartoum.

Dès lors il inaugura une série d'expéditions et missions au pays conquis dans le double but d'exploration et d'exploitation de ses richesses minéralogiques. Parmi celles-ci une mission archéologique fut confiée à l'illustre Champollion, et Caillaud et Linant de Bellefond remontèrent le Nil Blanc. C'est Caillaud qui le premier redressa les erreurs de Paez et de Bruce. "Le vrai Nil, dit Caillaud, est le fleuve Blanc dont le cours très étendu tire, selon toute probabilité, son origine des Montagnes de la Lune."

Mohammed-Aly expédia des missions à la recherche des sources du Nil, et en 1840–41 d'Arnaud Bey et Sabatier finirent par atteindre Régaf sis sur le Nil à 4° 42′ au nord.

Sous le règne d'Abbas Pacha de 1848–54 parurent les premières cartes hydrographiques de la Basse, de la Moyenne et de la Haute Égypte à 1,200,000.

Sous le règne de Saïd Pacha, de 1854–63, avait lieu la construction des chemins de fer, la concession accordée à de Lesseps pour la construction du canal de Suez; la découverte du lac Tanganyka par Burton et du lac Victoria Nyanza par Speke.

Le règne d'Ismaïl, de 1863–79, comme disait le docteur Schweinfurth, acheva le grand développement de l'Égypte, et l'impulsion qu'il sut donner à ce pays est son plus grand mérite; elle sera la plus grande gloire qui lui est due et lui sera comptée dans l'histoire. Sans lui l'Égypte attendrait encore le progrès et la prospérité dont elle jouit. Le savant docteur Abbate Pacha, président de la Société khédiviale de géographie du Caire, compare Ismaïl par son caractère et par la grandeur de ses vues aux trois grands pharaons du second empire, Ahmes II, Thotmes III et Ramses II, qui s'occupèrent expressément du développement des recherches géographiques.[a]

Ismaïl avait fait réorganiser son armée d'abord par une mission militaire française et ensuite lorsque celle-ci avait été rappelé en France en 1869, elle fut remplacée par une mission américaine.

Le docteur Bonola Bey, secrétaire général de la Société khédiviale de géographie (œuvre d'Ismaïl), disait d'Ismaïl Khédive:

Alors eut lieu cette longue série de reconnaissances, d'expéditions, d'annexions et de conquêtes qui en peu d'années firent de l'Égypte un vaste empire s'étendant des bords de la Méditerranée à l'Equateur et jusqu'au cœur de l'Afrique.

La géographie de ces contrées jusqu'alors imparfaitement connues put être définitivement établie par les travaux des officiers du gouvernement égyptien, sans compter le concours de nombreux explorateurs et de savants qui grâce à la généreuse protection que leur accorda le vice-roi, purent librement et sûrement parcourir cette partie de l'Afrique.

Sir Samuel Baker découvrit le lac Albert Nyanza en 1864. En 1868 le savant docteur Schweinfurth s'est avancé au cœur de l'Afrique par la voie du Bahr-el-Ghazal et pénétra dans le pays des Monbouttos.

Sir Samuel fut nommé par Ismaïl gouverneur général des provinces équatoriales d'Égypte en 1869. Le firman du gouverneur général comportait:

Considérant que l'humanité réclame la suppression de ces chasseurs d'esclaves qui occupent le pays en grand nombre, une expédition est

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[a] Un sommaire historique des travaux exécutés en Égypte sous la dynastie de Mohammed-Aly, Caire, 1890.

organisée afin de soumettre à notre autorité les contrées situées au sud de Gondocoro, de supprimer la traite des noirs et d'établir un système commercial.

Sir Samuel établit son quartier général à Gondocoro le 21 avril 1871, et le 26 il déclara solennellement la région environnante annexée au gouvernement égyptien. A la fin de son mandat le gouverneur général disait:

"J'ai laissé un gouvernement fortement établi, les indigènes paient régulièrement la taxe du blé; les chasseurs d'esclaves ont été expulsés du pays et dix-huit steamers sont en croisière sur le fleuve."

Cette expédition, pour obtenir ces résultats, coûta fort cher au trésor égyptien. Elle data du 8 février 1870 et ne prit fin qu'au mois d'août 1873. Elle coûta 20,000,000 de francs!

Ismaïl Khédive pourtant ne s'en laissait pas effrayer et tenta de nouveau en 1874 la conquête difficile de ces pays. Il nomma le lieutenant colonel Charles George Gordon, du génie de l'armée britannique, gouverneur général des provinces équatoriales. Les limites de son gouvernorat s'étendit de Fashoda au nord, au Gondocoro, ou bien Foueira, le point méridional où Sir Samuel avait refoulé les frontières de l'Égypte.

Le lieutenant colonel Charles Chaillé-Long, ancien officier de l'armée américaine, membre de la mission américaine et depuis cinq ans officier de l'état major général de l'armée égyptienne, fut désigné comme chef d'état major général du gouverneur général et partit du Caire avec lui le 22 février 1874.

Les résultats de cette mission à la fois militaire et diplomatique sont consignés dans les publications[a] citées et peuvent être ainsi brièvement résumés:

1°. Le traité stipulé entre l'Égypte et l'Ouganda en vertu duquel ce dernier pays fut annexé à la couronne Khédiviale.

2°. La découverte du lac Ibrahim (dit Choga) et la résolution définitive de la question des sources du Nil par la navigation de ce fleuve entre le lac Victoria et Foueira.

3°. La reconnaissance de la rivière Saubat et la découverte d'une route par terre à partir de cette rivière et aboutissant à Gondocoro.

4°. L'ouverture d'une route depuis Lado sur le Nil jusqu'à Gebel Baginsi à l'ouest. Occupation par des postes militaires du pays Makraka, Niam-Niam.

5°. Avoir ramené au Caire une femme de la race Akka[b] ou Pygmée,

[a] Comptes rendus de la Société de géographie de Paris, 21 juillet 1875; L'Afrique centrale, Plon, Paris, 1877; Central Africa, Naked Truths of Naked People, Sampson, Low, London, 1876; The Three Prophets Appleton, N. Y., 1884; L'Egypte et les provinces perdues, librairie Nlle. Revue, 1892; Une page d'histoire de la géographie africaine, Association Française, Congrès, 1900, Paris, pp. 1004–1013; Bulletins of the American Geographical Society, months of January and June, 1904.

[b] Les Pygmées, Quatrefages, pp. 255-260; L'Afrique Centrale, Chaillé-Long, pp. 275–276; L'Egypte et les provinces perdues, pp. 73–74; Bulletin de la Société khédiviale de géographie du Caire, No. 7, 1891.

seul spécimen connu sauf ceux ramenés du Soudan par Miani, voyageur italien.

6°. Expédition et prise de possession de la côte orientale d'Afrique, depuis le Socotra jusqu'à Kismayou à l'equateur; reconnaissance de la rivière Iouba.

Le traité entre l'Égypte et l'Ouganda, en vue des événements de ces dernières années, se revet d'une importance particulière et mérite qu'on cite ici la note officielle communiquée par le ministère égyptien aux représentants des puissances étrangères (note annonçant l'annexion des territoires acquis à la couronne khédiviale). En voici la teneur:

"D'après les dernières nouvelles parvenues au Caire, Gordon Pacha a définitivement pénétré dans le district de Mruli, sur les bords du fleuve Somerset, où on sait le colonel Chaillé-Long a essuyé, au mois d'août 1874, l'attaque à laquelle il a si courageusement résisté . . . Les populations sont soumises et tranquilles. Gordon Pacha a envoyé sous les ordres de Nour Agha, officier sûr et connaissant le pays, les troupes nécessaires pour former un poste militaire à Urondogani et un autre sur les bords du lac Victoria, près des chutes de Ripon . . .

Ainsi est accomplie l'annexion à l'Égypte de tous les territoires sis autour des grands lacs Victoria et Albert qui, avec leurs affluents et le fleuve Somerset, ouvrent à la navigation un vaste champ d'explorations que prépare en ce moment Gordon Pacha.

Nous sommes heureux d'avoir à annoncer le résultat de cette expédition qui a réussi grâce à l'initiative intelligente, à l'énergie et au dévouement de ceux qui l'ont entreprise sous la direction de Gordon Pacha dans la généreuse pensée de concourir au but que s'est proposé le Khédive, celui de féconder ces contrées par la civilisation, par l'agriculture et par le commerce.

Malgré l'annexion des provinces équatoriales à l'Égypte en 1874, le gouvernement britannique a émis la prétention en 1890 d'exercer sur elles son protectorat. Pourtant lors de l'incident de Fashoda, l'Angleterre a revendiqué non pas ses prétendus droits, mais bien ceux de l'Égypte contre l'occupation du territoire égyptien par la mission Marchand. D'ailleurs, le général Gordon Pacha[a] lui-même a fait une protestation énergique contre la prise de Kassala, également territoire égyptien, et dit:

"Dans le firman qui a nommé Thewfick il y a cette condition qu'aucune partie du territoire égyptien ne doit être cédée sans la permission de la Porte. De même en vertu du traité de Paris, comme celui de Berlin, l'intégrité du domaine ottoman est garantie par les puissances. Quelle est cette plaisanterie de dire que l'Égypte a cédé Kassala !

Les provinces équatoriales d'Égypte, et surtout l'Ouganda, font partie intégrale de l'empire ottoman. L'Angleterre indiscutablement les occupe en dépit de tous les traités existants.

[a] Colonel Gordon in Central Africa, p. 206.

FUNDACIÓN DE MÉXICO-TENOCHTITLAN

Por ALFREDO CHAVERO, Mexico

La fundación de la antigua ciudad de México-Tenochtitlan está consignada en varias pinturas jeroglíficas.

La más conocida, la más vulgar, digámoslo así, es la del códice Mendocino. Este códice fué pintado poco después de la conquista, por algún *tlacuilo* competente, en vista de las tradiciones y probablemente de otros jeroglíficos originales.

La pintura mendocina representa en el centro el águila posada sobre el nopal nacido en la piedra. Rodea la isla una agua límpida y azul, que la atraviesa en cruz, y la divide en cuatro partes. Alrededor del águila están los jefes fundadores de Tenochtitlan. Son, según sus nombres jeroglíficos: Tenoch, Mexitzin, Ocelopan, Quapan, Acacitli, Ahuexotl, Xomimitl, Xocoyol, Xiuhcac y Atototl.

Sembrada está la pintura de hierbas verdes que son el carácter figurativo de los tulares, y de azules que lo son de los cañaverales.

Tenoch tiene el rostro negro, por ser el jefe sacerdote. Mexi lleva en su jeroglífico el reverencial *tzin*, porque era el jefe guerrero.

Esta pintura pone la fundación de México-Tenochtitlan en el año *ome calli*, 1325.

Los Aztecas habían comenzado su peregrinación por lo menos cinco siglos antes. Arrojados de todas partes, y por último de Culhuacan, para salvarse se metieron en la laguna; y en ella el gran sacerdote Tenoch encontró al fin una isleta, y fundó la ciudad. Del nombre de su dios *Mexi*, y tal vez también de su jefe guerrero Mexitzin, se llamó México. Del nombre de su fundador Tenoch tomó el de Tenochtitlan. Con éste se le ve designada en los jeroglíficos, y así está en la pintura del códice Mendocino; pues el nopal sobre la piedra se lee Tenoch, y como nombre de lugar Tenochtitlan.

De este jeroglífico sacaron los Mexicas una fábula y una leyenda religiosa. La versión más característica dice así:

Un Axolohua llamado Cuauhcoatl, y otros dos, se fueron á examinar los lugares. Fueron á salir al paraje Acatitla, en cuyo centro se halla un Tenochtli sobre cuyo vértice estaba parada una águila. Al pie de este tunal estaba el nido del Cuauhtli, fabricado de diferentes y hermosas plumas del Tlauquechol, Xiuhtototl y otros distintos pájaros. De allí volvió el llamado Cuauhcoatl, y se puso á hacerles esta relación: Hemos ido á reconocer el camino y el cieno; pero allí ahogaron á Axoloa: ha

muerto Axoloa, según vi, por haberse sumergido en el carrizal donde se halla el tunal, en cuyo vértice está parada una águila y su nido al pie, formando un colchón de diferentes y hermosas plumas; y está donde se halla el agua. De este modo se formó el cieno donde se hundió Axoloa. También contó Cuauhcoatl que al otro día se apareció Axoloa, y le dijo: He ido á ver á Tlaloc que me llamó para decirme: ha llegado mi hijo querido Huitzilopochtli, y este lugar será su asiento y domicilio; él será el protector de vuestra vida en la tierra. Después de esta relación se fueron todos á ver el Tenochtli, y allí construyeron su altar, hortaliza y flechas. * * *

Esta leyenda tiene variantes en los cronistas: así, en el códice Ramírez y el P. Durán, vieron los Mexicas, discurriendo por la isla adonde habían llegado, una fuente maravillosa rodeada de sauces de hojas blancas, y el dios les habló y les dijo que ese era el lugar prometido: que al caer sobre una piedra el corazón de Copil, se había tornado tunal; y que sobre él habitaba un águila que de los más hermosos pájaros se mantenía. Al día siguiente todo el pueblo se dirigió con los sacerdotes á ese lugar, y encontraron la fuente de agua que se dividía en dos arroyos, el uno rojo y el otro azul; y en medio estaba el tunal sobre la piedra, levantándose encima una hermosa águila con las alas extendidas al sol, y teniendo en sus garras un pájaro de plumas resplandecientes.

Á tales fábulas dió origen el jeroglífico de Tenoch, que todavía hoy constituye las armas de nuestra bandera.

En el códice Vaticano 3738 está también la fundación de Tenochtitlan. Se ve la laguna con sus tulares, y en centro el tunal sobre la piedra. No tiene águila. Esta pintura es posterior á la conquista. Debajo hay escrito: *situs vbi fundata est Ciuitas Mexicana.* Da para la fundación el año 8 *tochtli*, 1318.

En la tira de Tepechpan se ve igualmente la fundación de México. Una águila, con el pico abierto, se posa en el nopal puesto sobre la piedra. Delante están los cinco fundadores con sus mujeres, y son: Aatzin, Acacitli, Tetlacheo, Tenoch y Xiuhcac. Fija á la fundación el año 7 *calli*, 1317. Es también pintura posterior á la conquista.

El mapa Tlotzin pone el nopal sobre la piedra, sin águila ni fecha. Es precortesiano.

En las pinturas de la Historia de las Indias de Nueva España del P. Durán, aparece en la lámina 3ª la fundación. En el centro está la laguna, y en su medio la piedra y el nopal, y sobre éste una águila que tiene con el pico y con la garra izquierda una culebra. Es la primera vez que se ve la culebra en los jeroglíficos de la fundación. Á un lado hay tres indios que contemplan el grupo; y al otro dos, de los cuales uno es el jefe, pues lleva manto azul, semejante al que tienen los reyes de México en las otras pinturas de Durán. No hay ninguna indicación de nombres ni de fecha. En la lámina 32 del mismo atlas de Durán, se repite la fundación. En el fondo hay dos altas montañas azules, sigue un lomerío verde, y en primer término está la laguna con sus tules significados de la manera acostumbrada siempre, grupo

de hojas verdes y puntiagudas que se abren á uno y otro lado. En el centro del agua está la piedra, de ella sale el nopal, y sobre éste el águila destroza un pájaro. Encima, se ve en el fondo del cielo el símbolo de la guerra: un escudo y unas flechas. Á los lados del nopal están sentados un hombre y una mujer, para significar que fueron los fundadores. No hay fecha; pero el hombre tiene el jeroglífico de Tenoch, y la mujer el de Tochcalpan. Estas pinturas son posteriores á la conquista.

En el códice Ramírez, en el dibujo respectivo, está la laguna con sus tulares; en medio de ella el nopal, la piedra y el águila que sostiene un pájaro en la garra derecha. Contemplan el grupo dos personajes á cada lado: los representantes de los cuatro *calpulli* fundadores. Este dibujo es posterior á la conquista.

En el códice Aubin, sobre el nopal puesto en la piedra, el águila toma una culebra con el pico y la garra derecha. Se pone la fundación en el año *ome tecpatl*, 1312. Este manuscrito de 1576, es cincuenta y cinco años posterior á la conquista.

En la segunda parte de mis Pinturas jeroglíficas, publiqué una lámina cuyo centro se refiere á la fundación de México. Es un dibujo á pluma, mal hecho, pero con mucho carácter, por lo cual lo creemos copia de un original mexica. El cuadro está dividido en cruz por las dos corrientes de agua; en medio está el nopal sobre la piedra, y encima de aquél el águila sin pájaro ni culebra. No tiene anotaciones cronológicas. En cambio nos da los nombres de los cuatro barrios que poblaron la ciudad: Tecpancihuatl, Chalmecatl, Tlacochcalcatl y Tepanecatl. En general, los otros jeroglíficos traen los nombres personales de los principales fundadores. Éste consigna el de los cuatro barrios. El códice Ramírez hace lo mismo, pero no expresa sus nombres. En la tira del Museo, por faltarle el fin, no está la fundación; pero se ve en Aztlan á la mujer Chalmecatl, á quien equivocadamente se había tomado por Chimalma, cuando á su jeroglífico le falta el signo indispensable de la mano. Al principio del códice Aubin aparecen los barrios peregrinantes; y ahí son: Cuauhtli, Apanecatl, Tezcacoatl y Chalmecatl, también representado por una mujer.

Tengo además un mapa de la peregrinación en pergamino, copia antigua; y en él la fundación está significada por el nopal sobre la piedra, sin águila, colocado en el centro de las dos corrientes de agua. Al lado están en cuadretes las figuras de los fundadores, y entre ellos Tenoch. Fija el número de los Mexicas en 2,400, y da por fecha á la fundación el año siete *tecpatl*, 1304.

Como se ve, todas estas pinturas fueron hechas después de la conquista; y aun cuando la Tlotzin es anterior, sólo pone el jeroglífico de Tenochtitlan sin ninguna otra indicación. Por fortuna existe una auténtica precortesiana, la cual nos va á proporcionar datos ciertos y seguros.

También es buena prueba, el encontrar en el cuadro histórico-jeroglífico de la Peregrinación de las tribus aztecas, como lo llama el Señor Ramírez, varios edificios con almenas. Basta abrir el códice Borgiano, para observar cómo los templos estaban almenados, y cómo la forma de las almenas variaba según la deidad á quien estaban dedicados. Los cronistas nos hablan del templo almenado de *Tlaloc.* Pues bien, los pintores postcortesianos, por ignorar eses pormenores, se olvidaron de almenar los *teocallis,* como puede verse dos veces en el códice Aubin.

Igualmente acredita la antigüedad del jeroglífico, la manera con que está representado el símbolo de la guerra: consiste siempre en una arma, sobre la cual está un escudo ó *chimalli.* Generalmente después de la conquista, esas armas eran flechas: ya citamos el Atlas de Durán, y podemos agregar el manuscrito Núm. 4 de la biblioteca de Berlín. Muchas veces el arma es una macana, como se ve en la tira del Museo. Otras es un *atlatl:* y así aparece en nuestro jeroglífico, pintado de amarillo para expresar el color de la madera de que estaba hecho.

No menos significativo es el grupo de Chapultepec. Una langosta inmensa en proporción del cerro; y una completa falta de perspectiva, pues están en el mismo plano la langosta, el cerro y los dos hombres pintados en él. Iguales defectos tiene el jeroglífico de Chapultepec en la tira del Museo.

Ya hemos dicho cómo se representaban los tulares en las pinturas antiguas, y puede además observarse en el jeroglífico de Tollan; pues así están significados en éste. Deben verse en la dirección de las figuras, y no al revés.

No es menor comprobación el signo de lugar Mixiuhcan, en donde hay una mujer en el momento del parto. Los indios figuraban á los hombres desnudos, y solamente les cubrían las partes pudendas con el maxtlatl. Por el contrario, á las mujeres siempre las presentaban vestidas, y aun les cubrían parte de los brazos con el huipilli ó el quixquemil. Pueden verse en confirmación, la lámina 88 de la Indumentaria del Señor Peñafiel, las mujeres del Lienzo de Tlaxcala, y varias diosas del códice Borgiano. Pues bien, á la mujer del grupo Mixiuhcan, le caen claramente detrás de los brazos las puntas del quixquemil.

Pero la mayor prueba de la antigüedad del jeroglífico de la Peregrinación, indiscutible y decisiva, es que tiene la cronología arcaica de los Mexicas, y no la correspondiente á la corrección hecha en 1454: luego fué pintado con anterioridad á esa fecha; por lo menos, más de sesenta años antes de la conquista. Y debió ser mucho mayor su antigüedad, según lo indica el carácter primitivo de la pintura.

Ésta, pues, por su autenticidad, es la mejor fuente para determinar cuanto se relaciona con la fundación de México. En ella está la laguna con sus tulares; las dos corrientes de agua azul que se cruzan,

y tienen en el centro el nopal sobre la piedra, que da el nombre de la ciudad Tenochtitlan; y á los lados las figuras de los fundadores, los cuales aquí son: Tenoch, Ocelopan, Axayacatl, Xomimitl, Acacitli, Atezcatl y Ahuexotl. El año señalado á la estancia en Temazcaltitan, ya en la isla, es 1313.

Por todos los datos anteriormente referidos, parece que los Mexicas tardaron hasta el 1318 en extenderse á toda ella, hacer construcciones permanentes, y levantar el primer humilde templo de Huitzilopochtli.

MORGAN'S JOURNEY DOWN THE MISSISSIPPI IN 1767

By Col. JAMES M. MORGAN

George Morgan was the first citizen of the United States who ever made the voyage down the Mississippi from the mouth of the Kaskaskia or Ohio River to the Gulf of Mexico. Butler in his History of Kentucky (1834) says:

> The earliest enterprise in navigating the Mississippi by Americans from Pittsburg to New Orleans was indeed one of boldness. It was performed by Colonel Taylor, of Kentucky, his brother, and Colonel Linn, who got as far as the Yazoo and then went to Georgia with the southern Indians in 1769.

The following fragment of a journal kept by Col. George Morgan while on his first voyage down the Mississippi proves conclusively that he performed the feat at least two years before Colonel Taylor and his party failed to accomplish it.

JOURNAL

On Monday, 30th of September, 1767, I set out from Philadelphia and overtook Mr. John Campbell and Joseph Hollingshed about 33 miles from the city.

I met with Place on his way to Philadelphia with news that two of our boats had been plundered on their way down the Ohio by a party of Indians, who had murdered all of our people. This induced me to go to Mr. Collender's to inquire more particularly into the affair, and wait at Carlisle for the rest of the party to come up.

On Sunday I left Carlisle, stopped at Bedford, and came right on to Fort Pitt (Pittsburg), where I was most politely and kindly welcomed by Captain Edmonstone, royal army, the commanding officer of the garrison.

At the Shawnee cabins I met with a Six Nation Indian who called himself John. Thirty-six days before he had cut his knee with a tomahawk, which glanced from a joint of venison he was cutting. He had been unable to walk ever since and had no one to procure subsistence for him but his wife. I gave one Thomas Hay, who lived near his hut, 25 shillings to buy necessaries for him and ordered as much more to be given him on my part if Mr. Croghan should not come up before that was expended. I ordered him to purchase 100 pounds of flour for him November 21. On Friday at about 11 o'clock I embarked at the Kaskaskia village, situate on the southwest side of a river of the same name, which empties into the Mississippi about —— miles from the town, in which there are about 70 houses, mostly built of wood and plastered on the outside, notwithstanding three fine stone quarries half a mile above the town.

Kaskaskia is situated on rising ground which has never been known to overflow, while all the lowlands along Kaskaskia and Mississippi rivers is yearly subjected to inundation in the months of May and June. In those months fever and ague have been remarkably prevalent insomuch that of the garrison and inhabitants of Fort Chartres few have escaped being more or less afflicted therefrom; and although not in itself mortal, yet the frequency of it must be the occasion of other disorders that are so; insomuch that there is not a single person, male or female, born on the Illinois, of French parents, who has lived to be 50 years of age. But the climate very well agrees with Canadians and Europeans.

The first night we passed Cape "Cinque Nommes," and about 2 leagues below we stopped to cook rations for the 22d, having come 24 miles from the Kaskaskia River.

On the 22d, at 1 o'clock in the morning, I awoke my people to embark, when at that moment a boat from Mr. Clarkson appeared. He had sent it after me, with letters from Philadelphia. Having answered the letters, I passed on, but the wind was blowing strong against us and it became very foggy in the evening. We came no farther than 45 miles, in the course whereof we passed the Kaskaskia tribe of Indians, who were encamped on the English shore to hunt for the winter season. They have a trader with them, whom I supplied for that purpose at their own request.

Sunday, November 23.—The past night and this morning there has been so great a fog that we dare not proceed until 9 o'clock, when we embarked and reached the Ohio before 11; up which beautiful river we proceeded 2 miles to the Clarkson's bateaux, where I rested until the next morning, a very heavy thunderstorm having come up in the afternoon.

From this point I wrote necessary letters to Messrs. Cole, Jennings, Clarkson, and Maisonville.

Monday, November 24.—The great fog this morning prevented our pushing off until 7 o'clock, when it cleared a little, but soon come on again when we got into the Mississippi. It was so heavy that we could not see the boat's length, which obliged me to put in to the shore again, where we remained until 10 o'clock, when we once more made a start, but, the wind being southeast, we made no more from the Ohio; in the course of which we passed three different hunting parties who had ascended the Mississippi from New Orleans for the purpose of killing buffalo, bears, which they salt up in large pirogues and bateaux and descend therewith by the beginning of December, to supply the inhabitants of Orleans. I visited one of their encampments and was kindly treated with bear's meat and buffalo excellently dressed in oil.

Tuesday, November 25.—The fog again prevented my starting long before daylight, and, the wind being stormy and ahead, we got no farther than the "little field," on the Spanish shore. During the day we passed other French hunting parties.

Wednesday, November 26.—Fog continues. We were not enabled to make much headway. Passed other hunting parties. Went on shore for meat, but could get none.

Thursday, November 27.—About 8 o'clock the storm abated and I pushed off, but at 11 it came on with such violence that I was obliged to put in to the shore, as I could make no headway against it. This detained me until after 12 o'clock, but in the interval one of my people killed a buffalo, which removed the fear that we might fall short of provisions.

Friday, November 28.—Embarked this morning at 6 o'clock, but the wind

coming out from the south, I could make no farther than the Heights of Margo, on the English shore.

Saturday, November 29.—Fog and wind continuing unfavorable, we came no farther than Consuls Bar, 36 miles from the Heights of Margo.

Sunday, November 30.—At half past 3 o'clock in the afternoon we passed the river St. Francis, about 30 miles from last night's encampment. The banks are low and, like the others, subject to overflow.

Monday, December 1.—Passed the Hermitage, 30 miles below the mouth of the St. Francis River; encamped opposite Iron Island, on the French shore; land low; soil rich.

Tuesday, December 2.—Made only 21 miles; passed several deserted Indian villages; encamped on a high bank on the English shore.

Wednesday, December 3.—At 1 o'clock passed the Arkansas River, opposite which is an island 15 miles long, on which is a small French fort and about 10 families. In the evening we encamped 15 miles below.

Thursday, December 4.—Made but little headway on account of the dense fog. Met two large pirogues on their way to the Arkansas from New Orleans. They had been out eight weeks.

Friday, December 5.—From the rain we had last night and the change of the moon I flattered myself that the wind would turn to the north, but the fog continued and was so dense the whole day as almost to deter me from proceeding on account of the danger of running foul of the many logs which stand upon end in the river. Passed Great and Little ——— and camped on the French shore.

Saturday, December 6.—Camped on the English shore.

Sunday, December 7.—Passed two French hunting parties, both on the English shore.

Monday, December 8.—This morning we embarked at 7 o'clock. Passed the river ———. There we overtook a pirogue going to New Orleans with buffalo meat. At night we camped on the French shore, 45 miles below. This is the first day the sun has shone since we left the Illinois. We could have made 6 or 8 miles more this day had we not seen a bear in the river which I was tempted to give chase to and finally shot. It proved to be a female, exceeding fat and fine eating. She measured 41½ inches around the middle and 5 feet from head to tail.

December 9.—Passed Grand Gulf. This is a remarkably short turn in the river and occasions a particularly rapid current in it, and gave rise to the name.

December 10.—Fog and rain continued.

December 11.—I embarked at 7 o'clock this morning and about 4 in the afternoon arrived at the fort commonly called "Natchez," from a tribe of Indians who inhabit the country. The fort was destroyed by the French in 1730. It is situated on a high hill, distant from the river 590 yards. There is at present a garrison of 44 men with 4 officers, a detachment of Scots Fusiliers, commanded by Captain Rhea, who took possession on the 29th of last September. This fort was built by the French in 1759 and deserted by them immediately after the treaty of peace, when it was, with all the country east of the Mississippi, ceded to the English.

December 12.—I tarried at Natchez to dry my potterie and take the latitude of the fort, which I find to be 31° 30′ north. Back of the fort are very extensive meadows, but the want of a horse and guide prevented my reconnoitering them and visiting the spot where the French and Indians had their villages.

Sunday, December 13.—We arrived about 7 o'clock in the evening at River Rouge, where we went on shore for the purpose of cooking to-morrow's food. About 50 leagues up this river is what they call the "rapids," and an Indian villag f the Avoyelles tribe, and about 50 leagues still higher up is the Natchitoche

another tribe, and a considerable French settlement. The Spaniards now have New Orleans and all of the west side of the Mississippi, which was given up to them by the French. This river will be the passageway for a considerable portion of the Spanish treasure from Mexico.

December 14.—Wind and rain prevented my making much headway this day. I met 4 Indian canoes containing several Indians each, and on the banks were encamped several hunting parties. In the course of the day's sailing, I passed 7 small French huts and about 40 or 50 negroes from Point Coupee engaged in cutting and hewing cypress so as to have it ready to float down to New Orleans early in the spring.

December 15.—I embarked this morning at about 5 o'clock and stopped at the first French settlement of Point Coupee, where I breakfasted and tarried until near 7 o'clock in order that I might have daylight to view the settlement as I passed. It begins 48½ leagues below Natchez and extends 21 miles down the river. It is protected by a small fort garrisoned by one officer and 26 men. Several of the inhabitants have 40 negroes, some 50, and few who have lived in the country any time have less than 5 or 6. The banks are high, the lands are good, and in a few years the occupants will become rich. I had a pleasant gale in passing the place and took great satisfaction in seeing my English colors fairly exposed to the view of the old masters of this great river, who excitedly came forth from every house to gaze at them. When we were passing the fort the sentry hailed and ordered me to come on shore, but seeing my colors thought it better not to insist on my paying them that respect. My bateaux men, who were principally Frenchmen were in great trepidation at my resolution to pass without visiting the commanding officer lest we would be fired upon. At about 7 in the evening I arrived at Fort Bute, situated near the Iberville ditch. I tarried here the 16th, 17th, and 18th to see the Iberville River so much talked of as a passage of importance to the English nation, and the boundary between the French and English colonies.

COLLEGE ENTRANCE EXAMINATIONS IN PHYSIOGRAPHY

By Prof. W. M. DAVIS, Harvard University

[Abstract.]

A student's knowledge can not be so well tested by examination in subjects which are taught only through the presentation of large problems and general relations as in other subjects which treat their problems more minutely and precisely. If a subject of study is to have a place among college entrance examinations, it should be taught, if possible, so that strict examinations may be set upon it: otherwise it will fail to secure the respect of its students. It will fall into deserved disrepute when its students discover that a light preparation will secure a passing mark. There is to-day some danger that such a fate may overtake physiography. This danger may be averted if current methods of teaching this broad subject are so amended as to give it a sufficient measure of precision without lessening its general value. Examinations may then be framed so as to secure a thoroughly respected rank for physiography, even in comparison with classics and mathematics. An important factor in the desired change is the development and introduction of practical laboratory exercises, through which the student may make a closer acquaintance with phenomena than he can through the study of a text alone, on which critical and disciplinary examinations may be fairly set.

DISCUSSION

Professor BRIGHAM: The question here, it seems to me, is simply how fast and how far we should raise our requirements toward the ideal. It has fallen to me to encounter this problem in a very practical way in having to do for the last three years with settling questions in geography that have come before the college entrance examination board. We have had constantly to ask how difficult and how precise we should make our tests. We must stimulate and require progress, but we must not discourage by holding up impossible standards. To cite particular subjects, we should agree that

meanders, or river terraces, are suitable for questions, yet we could not call for all that should, from the ideal point of view, be known by the student on these forms. I fully agree with Professor Davis that progress must be made through the means of practical exercises, by which the student will acquire precise knowledge and be able to meet more strenuous requirements. We may, therefore, be quite assured that our difficulties are temporary and will in no distant future be relieved.

GEOGRAPHY AND HISTORY IN THE UNITED STATES

By Prof. ALBERT PERRY BRIGHAM, Colgate University, Hamilton, N. Y.

That geographic conditions have power in human affairs is known to all, but their scope and importance are appreciated by few. We can not ascribe all that we do, or experience, to geographic sources, and we must draw our conclusions with caution, for personal and racial traits come in whose origin we can not trace. We may safely reject, however, the phrase "theater of history" as it commonly used. The earth is more than a mere stage. Ground to stand on, a background to look at, and even machinery to produce new effects, do not express the relation of earth to the human drama. The bond is closer, and might be called organic, bearing its share of the complication and mystery that belong to life everywhere.

The writer has elsewhere sought to show the greater relations which obtain between the American land and American life, and can here select but two or three examples which seem to have the force of types, and these will form a basis for the emphasis to be laid upon correlating these two great branches of knowledge in American schools.

We take our people of the western world as we find them. It is a race ancestrally molded by environment, but man must long be studied from the combined points of view of history, geography, and biology before the unknown geographic factor in the equation can be brought out. Given the early Americans, they were affected by local influences which told, in the resources of rocks and soils, in climate, in lines of commerce, modes of communication, in the planting and growth of cities. We pass these and we pass by also the less obtrusive, but doubtless more compelling influences of sea, of relief, and of climate upon the inner man, upon thought, imagination, and moral convictions.

We have taken certain larger regional and, indeed, we might say national exhibitions of geographic influence in the temperate portions of North America. In so doing we must remember that our history is short and that we see it in its making, in its more

creative stages. But thus to see it is to have a blurred vision, it may be, of some of its most distinctive characters. Until recently we have had as a nation a migrating frontier, an ever-shifting "West," repeating with variations the features of frontier life, furnishing outlet from the more settled regions, and reflecting the influence of new conditions of society and of new products of the earth back upon the older populations. Some of these older regions have seen swift changes therefore, despite the persistence of their soils, their minerals, their reliefs, and their skies. Thus we have widening circles of adjustment in larger and larger fields.

Or we may say that the process of adjustment is twofold. There are local adaptations, as in periods of first settlement when most of man's necessities are won from the soil at home; and there are adjustments in relation to other regions, hinging upon more favorable communications, and upon products of special regions, the law of competition coming in. The former sort are known and utilized in some measure in the teaching of our schools. We are but beginning to know the latter, and can know them only from the point of view of the historian and the economist.

Our first example is New England. Here nothing less than a revolution has taken place, and, indeed, is in progress before our eyes. When the early colonists sought the protected waters of the shore and the fertile lowlands of the Connecticut, or cleared their rough fields and challenged the uplands to give them a living, or snared it beneath the salt waters, there was abundant geographic influence and there was genuine adjustment to the conditions of the land. But if we look at the New England of to-day, we see many new things. The fishing has waned and what there is concentrates itself chiefly at one port. There has been a decline, so called, of agriculture, but perhaps no diminution of the value of the products of the soil. Boston is said to be second in this particular among the towns of Massachusetts. That the growths of the greenhouse must be counted in to make this true, only points to the great fact of specialization of tillage. It is now tobacco in the Connecticut Valley, cranberries on Cape Cod, and truck farming adjacent to innumerable cities, instead of a toilsome struggle to raise breadstuffs everywhere. Fields which are too steep and too rough with bowlders to favor the plow, are relapsing into forest, to become valuable to the next generation at least for refreshment, and to later generations, it may be, for lumber as well. Meantime the population of the region has increased, its wealth has grown, and its array of comfortable conditions of living is out of all comparison with the days of the fathers. What now are the larger connections in this chain of events? We find them in early migrations to New York and Ohio, the "West;" in

the wheat fields of the Genesee Valley; in the expansive acres of Illinois and Iowa; and in the silver and gold of Colorado and California. Certain industries could be better carried on if New England men and others were to follow the fleeting limit of our country toward the setting sun, and the old New England, mourning less about herself than others have mourned about her, set herself to do the things that she could do best. No water power could be more abundant, no seashores more attractive, and few harbors more inviting than those of New England. Manufacturing, commerce, a considerable range of mineral industries, and the care of resorts among the mountains and by the sea may not unfairly be said to mark the more assured and final adjustments of life to land in this region, whose bread can better be won by exchange than with the plow. Adjustment and control are marked by wider range. But even in her special field of the factory there is a qualification. Abundant as water power is, coal is yet important, and must come by a long haul. And the haul for cotton is yet longer. The South is awakening, and a region which has water, coal, cotton, and labor in juxtaposition is likely to win in the race. Time will impart the needed skill to the southern operatives, and New England manufacturing must turn in the main to other lines.

Professor Hinsdale has remarked upon the prodigious importance to the old Northwest of the fact that on the one hand it belongs to the upper Mississippi, and on the other is closely associated with the Great Lakes. Thus in a word is summed up much of the history of the prairies. Speaking in detail we have first what we may call prairie conditions, land that is mainly flat and low-lying, in a forestless state, a fairly moist climate, and, owing in part to its lack of relief, a land fitted to accumulate a soil of surpassing richness. Water power is for the greater part absent, but there is abundant coal. These conditions mean the dominance of agriculture, easy local communication, and the ultimate growth of manufactures. The critical questions of geographic adjustment arise in connection with long-distance transportation. It has been said that the railroads raised up Chicago and determined New Orleans to an inferior position. But this does not tell the whole story. It is true that railways waxed as traffic down the Mississippi waned, but it is difficult to weigh the share that lake shipping has had in making Chicago. It is also true that railways fall back upon geographic conditions—easy grades along the old lake plains to the eastward, the open Mohawk Valley with its Erie Canal, the tidal Hudson, and New York at the western end of the Atlantic ferry. But it remains to be seen how the old Northwest will be affected by railways to New Orleans and Galveston, by an extended drainage canal and a ship

channel across the Isthmus of Panama. In brief, the East and the South have long been striving for the prairie country, for it stands balanced between the one and the other. The easy grades and shorter haul down the Mississippi, added to American developments all about the Mediterranean of the Western Hemisphere, may compensate for the longer passage from the Gulf ports to Europe, and may weaken the bond between the prairies and New York. The more is this result possible now that for more than a generation slavery has been wiped out, and steady assimilation of social conditions between the upper and lower Mississippi regions can proceed. The old struggle is on, which gave Washington and the fathers so much concern in their time, as to whether by roads and waterways they could render nugatory the divisive influence of the Appalachian barrier. The sturdy men that won the old Northwest came in by the Cumberland Gap, and the men that subdued and populated it came by the Seneca turnpike or through Pittsburg, but the ancestral homes of New England can not be forever remembered, nor will the man of the prairies maintain loyalty to New York when his interests point to the Gulf of Mexico.

We take a further example in the development of the arid lands. The basal motive can not be counted as other than the wealth of minerals in the western mountains. Once prompted to test the possibilities of the dry plateaus of the cordilleran country, they have been found to have values of their own, making them no longer merely subsidiary to deposits of gold and silver. The Kansas problem and the unhappy inflation of the decade following 1885 had their origin in ignorance of geographic conditions. A temporary increase of rainfall was thought to betoken a permanent and benificent change of climate. Hence came an era of speculation and foolish spending, of boom towns and excessive railway building, of reckless borrowing and inability to pay interest, of bankruptcy and foreclosure. With this unhappy harvest of distress came wild-cat theories of money, misunderstanding and bickering between East and West, and great loss and suffering on the part of lender and borrower, until the bubble collapsed, until overpopulation was checked, and most of those semiarid lands were returned to grazing. Thus we approach the deeply characteristic development which arid-land life must have. There will be tillage where there is water enough for it, and grazing over wide intermediate spaces. And in the areas of tillage population will be dense, will approach the conditions of the town, and the interests of the people will link them to each other in semicommunistic ways. These conditions of solidarity will work themselves out in the school, the church, in economic relations, and in the very life and quality of the men that make up such a society. And the nation

itself, by adopting an irrigation policy, has not only prospectively increased its wealth and its census roll but fosters thereby a modified and highly specialized type of society.

Final, or at least larger, adjustments are hinted at in our expansion of territory, in binding to ourselves more or less closely lands across the seas and in the enlarging commercial bonds which join us to other lands. We can hardly emphasize too much the fact that we stand between two oceans. The Pacific now looms in importance, and we are pointed back to our primal geographic-historical fact that we fronted Europe and were thus approached on our more open side by several colonizing peoples, of which one, perhaps in defiance of geographic obstacles, became dominant.

We now come to the question whether these great relations between history and geography are properly recognized in the literature of the two subjects and in the schools. We shall do historical literature no injustice by affirming that it is generally deficient in a real understanding of relations to the earth. The quality of regions and of national domains is but partly realized. There are plains, there are mountains, there are rivers; there is impressionistic painting but little photography upon the pages of the historians. In like degree geography has failed to avail itself of the rich interest which history offers, with its wealth of human elements and its causal associations running through time, and its economic and social relations giving easy unity to wide regions or remote nations.

If we inquire for correlation in schools the answer is little better than negative. Certainly geography should be fundamental and should in some measure precede, while history should follow, and should not only be more intelligible, but should contribute new fascination to geography. The teacher of geography must know the essentials of history and should be well schooled in the history of his own people; and the teacher of history is but half fitted for his task if he does not know the principles of geography and if he has not a generous knowledge of the geography of his own country.

Such correlations, whether in the teacher himself or in school programmes, are rare. And yet correlation is peculiarly possible with the common plan of one teacher for all subjects in a grade, and in the department system only requires some planning on the part of directors and teachers. But the teacher will often wait long for aid from his superiors. As it was put by another, "It is no uncommon thing for a class to be studying at the same time the geography of Africa, the history of England, the plant life of Minnesota, while having for their reading lesson the story of Peter the Great." But, barring repressive systems of examination, there is no limit except of time and interest to the amount of history that a teacher of geography may

know and use or to the history teacher's use of geography, each, of course, making the other subject subsidiary to his own. In this respect we seem to be far behind Germany, where the two subjects more often are handled by the same teacher. We need not, however, wonder that we are backward when we see geography just escaping from its thrall as a locational study, and when the first association in this country for improving educational methods in history dates from the Nebraska organization of 1889.

Professsor Howard criticises the report of the committee of seven to the American Historical Association as disappointing in the matter of correlation. He, however, lays stress here on law and economics, while we would place it without question upon geography. In fact, the one passage of the report that touches geography with emphasis, serious and true as it mainly is, is amusing in its assurance. "Fortunately," says the passage, "it is unnecessary in these latter days to call the teacher's attention to the use of maps and to the idea that geography and history are inextricably interwoven." This would be pleasant if it were true. The use of wall maps, physical maps, and of a historical atlas is recognized, and we are told that "pupils should not lose sight of the physical causes that have acted in history." But what if nine-tenths of the teachers are densely ignorant of these physical causes? The best thing in the passage is quoted from Hinsdale, who says with freshness and power: "Groupings of historical figures and scenes around geographical centers make these centers themselves; binding the figures and scenes together gives them a new permanence and solidity." Aside from the one passage, there is little reference to geography in the report, and the implication is that locational geography and a rough knowledge of the principal reliefs is all that is needed. Dr. C. A. McMurry, in his Special Method in Geography, has given pointed expression to the importance and feasibility of such correlation as is here under review.

One of the more satisfactory utterances on this subject is found in the report of the history conference to the committee of ten, as follows: "From the beginning the teacher should attempt to connect physical geography with the present political condition of the world, and, in like manner, the study of political geography should constantly bring in the physical features." Even more emphatic is the formal resolution of that conference: "That the study of history should be constantly associated with the study of topography and political geography, and should be supplemented by the study of historical and commercial geography and the drawing of historical maps." Good as this is, we may read between the lines even here the "theater of history" idea rather than the very ground and conditioning element of history. Thorpe, in an essay included in the volume on the Study of History in American Colleges, observes,

"That study [history] should be at first chiefly geographical and sociological." He is speaking here of the public school. The college entrance examination board might well go further in its syllabus of history than this: "Geographical knowledge will be tested by requiring the location of places and movements on an outline map." This might have been written a hundred years ago if history had then counted for admission to college.

What is proposed to be done, in view of the need and of the evident gains of such correlation? We have no scheme to outline, but we hopefully recognize an awakening interest and excellent beginnings. Within a brief time formal works on the interrelations of geography and history have begun to appear. There is a profound interest in this field on the part of all progressive geographers, and a considerable number of pertinent articles have appeared in the geographical journals during the past five years. Several of the later historians have also recognized the intrinsic (if we may so term it) value of geography. To Francis Parkman must be given the honor of being the pioneer in this splendid field. If to him a region is a theater, it is a stage that glorifies with its native colors every deed that emerges upon it, and the reader knows that he has seen no manufactured setting, but the very home and fertile soil where historic deeds have matured. Fiske and McMaster are not far behind the great master of lake and forest, and it is worthy of note that for a part of its next annual meeting the Association of History Teachers of the Middle States and Maryland have arranged a session for the discussion of such problems of joint interest.

These indications point to a vital growth which will bring about the needed organization and will develop suitable school programmes. We shall, as time advances, have more teachers of geography and of history, specialists in chosen fields, and neither will be deemed fit for his own subject until his interest and his first-hand knowledge take him far over into the other.

DISCUSSION

Prof. W. H. Norton: Two examples occur to me illustrating physiographic influence of kinds which I believe have received little or no mention.

Eastern Iowa was settled by migrations—if I may term them so—from several regions, among them a distinct emigration from the mountain-plateau regions of the South. Coming into Iowa, these emigrants were attracted by the lands most like those which they had left. They turned aside from the wide drift plains and settled in deeply dissected and relatively infertile areas of the older—the Kansas—drift. There we find them in colonies to-day, preserving almost

intact their dialect and their architecture, as well as their poverty and their illiteracy.

Another field in which physiographic influences are as seldom looked for is the history of schools. The denominational colleges of the Middle West of the United States were planted with a profusion which made necessary the operation of the law of natural selection. They were at first without endowment, and the survival and growth of some of them which have become large and wealthy schools may be traced, in a small degree at least, to certain initial advantages in location and means of communication.

OBSERVATIONAL WORK FOR CHILDREN

By FRANK CARNEY, Denison University, Granville, Ohio

In this country observational work for children is a matter of theory rather than practice. However much teachers who are particularly interested in geography may be gratified with the "new geography," they can but lament the lagging of this very important side of the subject. And its importance does not end with the study with which it is connected; it touches much of the whole primary programme, besides being an asset in the grammar and high school work of the student. When teachers and school directors appreciate this fact, observational work will be insisted upon, whereas its practice is now largely a matter of sufferance.

The advantages to children of this method of study must be real and obvious if school superintendents are to indorse it; the men who are responsible for the efficiency of our elementary and grammar school work have delicate adjustments to make in their present crowded schedules. The simple school programme of our fathers has been variegated and expanded quite to its maximum. Nevertheless, the problem of the present in the elementary grades is one of correlation not retrenchment; little sacrifice should be made in variety of training, but careful attention should be given to the matter of useless duplication of work and to dissipating the energy of pupils. Whatever gives promise of minimizing these two conditions should be well considered, if not empirically investigated.

But before we can see observational work in operation in many school systems of even moderate size we must have a changed attitude in either one or both of two educational exponents—the graded teachers and the superintendents of these systems. When enough of the teachers in a system of schools become convinced that this side of geography work is worth while, without doubt their wishes will be respected by their superintendents; or when the superintendents are satisfied with the wisdom of thus investing time and energy the teachers will be pleased to cooperate. It is certain, however, that while superintendents in general indorse the observational phase of

geography teaching, they demur on the ground that they can not find a place for it, or that their teachers do not succeed with groups of children out of the class room. Other reasons have been stated to the writer, but these two are most frequently given. The first objection disappears with the conviction that the work gives educational returns; the second is a premature conclusion due to conditions which we will consider in another connection. Another objection, less commonly urged, but much more pertinent, is the teachers' lack of training for carrying on observational work with their classes, and few superintendents have been able to give the subject very special attention. Preparation for the work on the part of the teacher is to be desired. With the wide-awake teacher this lack of preparation is not a formidable objection. The numerous and still increasing number of summer schools ought to give an opportunity for the hesitating teacher to acquire the confidence needed. Indeed, a great deal might be done by our State departments through the institutes, city and county.

Nevertheless, the hesitation which teachers have in reference to taking up observational work with their classes is for the present an important consideration. This hesitation is due in part, as just stated, to a lack of special training, to timidity in managing children in the field, and also to want of time. The removal of the first cause rests with the teacher; suggestions for this work may be found in books, in current educational literature, and in published courses of study; an investigation of the home locality, physical features, manufacturing and commercial interests will show the extent to which these suggestions may be applied, and may also reveal many possibilities entirely local. The second cause comes either from expecting too much of children or from too brief an experience with them in the open. It must be remembered that the novelty of the situation has an exuberant effect on the youngsters the first time or two in the field; anyhow, it would be exceedingly surprising to find pupils taking out into the sunlight and exhilarating atmosphere their indoor decorum. As teachers, perhaps we should, if necessary, cultivate an adaptability to juvenile outdoor feelings. More serious in its bearing on the problem is the lack of time; every lesson in observational work should be prepared thoroughly. For the novice this means much extra effort, the first year at least. Furthermore, if the trips are taken the last period of the afternoon session, as may be done for the near-by excursions with least inconvenience to the programme, that half day's work may be lengthened some. No enthusiastic teacher will find it very discommoding to give this additional time to the progress of her classes.

This increased tax on the teacher, however, has its compensation. She becomes more efficient even in the estimation of children, who

appreciate freshness of information and freedom from books; this feeling of pupils in the primary grades is akin to that of high school or college students for instructors who are also investigators. On the other hand, of far greater importance is the teacher's growth in intrinsic efficiency. As teachers we learn much from books, lectures, etc., but this learning does not insure successful teaching. It may make possible a dangerous kind of mental stagnation. The teacher who year after year is an inspiration to pupils keeps in touch with more than text-books; one source of such inspiration is the field study necessitated by observational work.

SOME DETAILS CONCERNING OBSERVATIONAL WORK

For obvious reasons the number of pupils usually allotted to each teacher in the grades is more unwieldy, from the standpoint of good work, out of doors than indoors. Under ordinary circumstances 20 pupils should be the maximum number for observational work. Best results, therefore, follow making each trip in two sections, the substitute or practice teacher taking charge of the section left at their desks. No other part of the work, preparation or discussion, needs to be thus duplicated. If proper ideas prevailed among the supporters of our public schools this repetition would not be required. A teacher should never have more than twenty pupils. Under our present system the Batavia method of having two teachers for each room lends itself easily to this division for outdoor work.

To be most effective observational work must be a regular part of the programme. All teachers who have tried out-door exercises understand that for the first time or two the children do not get entirely away from the picnic or frolic idea. Again, the repeated appearance on our streets or in the parks of a teacher and her group of pupils will shortly educate the general public out of its present glaring wonderment; we lament that in the minds of so large a portion of the American public education means the elimination of first-hand knowledge. A regular time at stated intervals for the observational work will place it in the child's mind on a par with his other school duties. One or two trips in a season have little more value as an aid in geography than has any other outing.

All outdoor exercises should be preceded by a class-room consideration of the chief features of the trip. If a factory is to be visited, ascertain in this discussion what the children know of the raw materials used, of the methods employed, of the products, etc. This particular factory may mean food and clothing to some of the pupils; their parents may be operators, or otherwise connected with the plant. Suppose you plan a field study of soil, or that you are to visit a garden, a nursery, or a farm; pupils in even the lowest grades

can contribute some information to a preparatory discussion of these topics. It is a trite expression that we never know a subject till we teach it; in a similar manner the child is made stronger by imparting information to his class-room companions. An anticipatory interest should figure in all observational work.

Children on these field trips should be directed in reference to points intended for their note books; it has sometimes been thought best to have the notes taken by every third or fourth pupil, all using these notes later in the class room. In the advanced primary and in the grammar grades each child should make field notes. In general, pupils from the elementary schools are more spontaneous in their questions than are high school or even more advanced students. Possibly this is because they have not reached the point of self-consciousness that dreads putting a question which may reveal even excusable ignorance. This inquiring spirit necessitates the wisdom of the teacher suggesting the particular topics she would have the class enter in their record of the trip.

The trip having been made, the next geography period should include a further discussion, broader and more thorough than the preparatory consideration; in this the children themselves should take the major part; to the former the teacher contributed much. This summing up of the trip should be followed by a written report; the composing of this report is language work, differing possibly from the regular language work in having more spontaneity. A record of the trip should be made by each pupil, the disconnected sentences of the lower grades having as much educational value as the more pretentious compositions of the older children.

GENERAL SUGGESTIONS

If a scheme of observational study has yet been worked out and tried the writer knows nothing of it; in several places work has been undertaken with one or more grades, but the real test of this, as of any other educational effort, is its graduated application to a complete course of primary study. Evidently such a scheme would be a matter of particular rather than general development. The size of the city or village, the economic and agricultural environment, the transportation facilities, the physiographic surroundings, the length of the open or field season, are factors that must figure in the order and nature of the work undertaken.

Nevertheless, there are in almost every locality some basal phenomena which may be considered: Where men are congregated stores or markets exist; each region has its own products which seldom have a range equal to the necessities and luxuries used; therefore these stores and markets illustrate the products of other regions; weathering is universal, consequently the genesis of soils is a general topic;

wherever there is rainfall the action of running water may be observed; rare indeed are the places from which some products—food or manufactured or raw material—are not distributed, the shipping station thus bringing the child in touch with the necessities or luxuries of his more distant fellows; a building in process of construction centralizes materials otherwise disconnected and brings them together, too, in a lesson that makes instant appeal to the child; even in the humid climate, which characterizes the sections of our country most thickly populated, there are occasional seasons of drought, when we may observe the early stages of a region becoming arid, the grasses first succumbing to the want of moisture, the higher plant forms following.

While concrete illustrations and lessons must always be characteristic of observational work, it should not be approached with the idea that the particular investigation carried on with children is an end in itself. This work has in common with every study connected with nature, or with the interaction of man and nature, an inspiring culture value. The information which children get out of the work is not of chief importance; the discernment it gives them in the relation of controlling influences is of greater value.

And yet we question whether observational work as thus outlined would deserve a place in the primary programme if it concerned geography alone. Such work requires time in itself, time in supervision, and time in preparation on the part of the teacher. The outlay does not warrant the investment if a single study—geography—is to receive the income. The fact that it is a profit-sharing scheme will be the reason for observational work eventually having a fixed place in school curricula. History, language work, arithmetic, drawing, and the pre-high school observational sciences, all may be enlivened through this outdoor geography study.

The correlation of the activities of men makes history; the trend given these activities by the earth is the more essential side of geography. Naturally, then, there is great variance between localities in their richness in the joint field illustrations of these two studies. We may feel that our city or town was founded so recently that it has little local history. But let the class visit the oldest building; among other queries occasioned by this place of historic interest arises the reason for its location. The explanation may or may not account also for the town's location. The child should early understand that centers of population are not of accidental distribution. Again, a trip to a flour mill affords the right opportunity for fixing the history of the shifting of the milling industry in this country. Some facts connected with the history of railroads will be more to the point after the children have inspected a freight house, noting what is being shipped and received, the cars of various companies, etc. If

your region is one rich in historic associations, so much the better. Strategic points in colonization or in war are seldom divorced from geographic causes.

We have already referred to the correlation of this observational work and language study. Children, no less than their elders, experience a minimum of inconvenience in reproducing what they know at first-hand; it is the attempt to rehash that inspires the feeling of repressive vacuity.

The alert teacher will be pleased with the number of live problems and computations these excursions suggest for the arithmetic period. The zest with which children handle this number work prompts many reflections in regard to the years pupils are made to study text-book arithmetic.

Sketching should be a part of the note taking in much of the field work. Sometimes this drawing in the field should be done with care, as carefully as outdoor working will permit; frequently, however, a rough field sketch with indicated measurements, etc., may be reduced to greater accuracy during the regular period for drawing.

It is needless to comment on the best place for studying plants, birds, insects, animals. A field trip with children given entirely to geography is like a train trip on which the passenger sees only the interior architecture of the car. One of the objections to this work with juveniles, it has been urged to the writer, is that children see too much. This gratifying condition invites manipulation rather than suppression; it is always easier to direct a situation than to create it.

This phase of geography teaching is common ground for most of the primary programme; its correlation possibilities are obvious; its practice is invariably indorsed by the children, who often are wiser than we concede them to be.

GEOGRAPHY IN THE NORMAL SCHOOLS OF THE UNITED STATES

By Prof. CHARLES REDWAY DRYER, Terre Haute, Ind.

FUNCTION OF NORMAL SCHOOLS

The public school system of the United States includes about 145 State normal schools, whose function, as generally defined in the act of establishment, is the preparation of teachers for teaching in the common schools of the State. By "common schools" are meant those in which the primary and grammar grades, comprising the first eight years of the school course, are taught. The "common branches," or those which are universally taught in the common schools, are reading, writing, arithmetic, grammar, and geography. To these some States add human physiology, history, English literature, music, drawing, nature study, and, more rarely, algebra and Latin. The fundamental work of the normal school is to give instruction in the common branches and in "professional" studies, comprising pedagogy and its various cognate subjects. Most normal schools also provide courses of study in some of the secondary, academic, or collegiate branches of learning, which may prepare students to teach in the public high schools.

STANDARDS OF ADMISSION

The nominal standard of admission to the normal schools is the completion of the eighth grade of the public schools or the possession of a teacher's license obtained by the regular county examination. A few normal schools require a diploma from a public high school for admission, but usually special courses of study are provided for such students.

COURSE OF STUDY AND PERIOD OF ATTENDANCE

The normal course of study required for graduation varies from one year to five years, according to the rank of the student at the time of admission. For the majority of students the length of the course is four years. Probably, on the average, not more than one-third of

the students admitted remain until graduation, and about one-half attend the normal school one year or less. The majority enter for the purpose of preparing themselves to obtain, for a limited period, higher grades of license and fair positions in the common schools, with no intention of teaching as a permanent occupation. Consequently the freshman or first-year class is apt to be very large and the ranks of the upper class to diminish sometimes to one-fifth the number of freshmen.

POSITION OF GEOGRAPHY IN THE NORMAL SCHOOL COURSE

Geography, being one of the common branches and required for all grades of license to teach, falls, with few exceptions, in the first year of the course, and is taught to students who have had the least preparation. From the pedagogical or scholastic point of view, geography may be differentiated into two well-marked varieties: (1) Introductory geography, which gives in broad outline a general view of the world and its physical, biological, and human activities, and serves as an open door to all the natural, historical, and economic sciences; and (2) advanced geography, which comprises a synthesis and correlation of natural science, history, and economics. It is evident that under the conditions which prevail in the normal schools, all but a small fraction of the geographic work done must be of the introductory variety.

LACK OF PREPARATION ON THE PART OF STUDENTS

For the normal school-teacher of geography a serious problem arises from the imperfection or absence of preparation on the part of the students. The State courses of study for the common schools include no more than four years of geography, which the child pursues between the ages of 9 or 10 and 13 or 14. In many cases, by the downward intrusion from the high school of algebra, Latin, or German, this has been reduced to three or even two years, and the child "finishes" geography at the age of 12, when he is just beginning to be able to think. Ten or 20 per cent of the high schools give a half year or a year to physical geography, which is often very poorly taught by any teacher who happens to have a vacant period upon his programme. The high school course is usually a convenient period in which to forget the little geography learned in the grades. The result is that the knowledge of geography possessed by the average normal freshman is difficult to evaluate. It may consist of a mixture in various proportions of blank ignorance, disjointed facts, parrot phrases, and less desirable pieces of pure mythology which stand in the place of scientific explanation. A most lamentable fact is that the geographic knowledge of the stu-

dent lies so remote from his experience. He has wrestled with such problems as the change of seasons, the cause of tides, and rotational deflection at an age when it was impossible for him to understand them, and has never observed the path of Ursa Major or the varying points of sunrise and sunset. He is apt to know something about Tibet, Abyssinia, and the Amazon, and nothing about the hills, valleys, and streams of his own neighborhood.

The school geography of forty years ago consisted largely of memoriter recitation of names and locations. This was often so thoroughly done that the child retained through life a very practical knowledge of general descriptive geography. If it were well done to-day, it would furnish a foundation for teaching scientific geography in the high and normal schools. Memoriter learning has been largely abolished from the grade schools, but scientific learning has hardly begun to come in. The house is empty, swept, and garnished, and its last state is worse than the first.

PROBLEMS OF NORMAL SCHOOL GEOGRAPHY

The normal school is called upon to undertake such large tasks in geography as the following:

(1) To teach the student to read and use the technical language of geography as it is embodied in maps, including the higher forms of that language, such as colored, hachured, and contoured topographic maps, population, product, and weather maps.

(2) To teach a large part of the subject-matter of geography. It is never safe to assume that the student possesses any particular portion of it. The subject-matter should be so taught that the student may realize his concepts, and build up in imagination true and adequate models of the features and phenomena of the globe.

(3) To give the student some insight into the methods of scientific investigations and lead him to appreciate the meaning of natural or scientific causation.

(4) To make clear the scope and organization of the science of geography and its relations to other sciences and subjects of study and to practical affairs.

(5) To ground the student in rational methods of teaching geography to common school pupils.

In view of the magnitude of these tasks, perhaps criticism of the results of geographic teaching in normal schools should be more considerate.

STATISTICS OF NORMAL SCHOOLS

An attempt has been made to ascertain what the normal schools are actually doing in discharge of the heavy geographic responsibilities laid upon them, but with only partial success. An elaborate printed questionnaire addressed to more than 100 normal schools

brought but 28 replies. The causes of this meager response may be left to conjecture. Partial information was obtained from the catalogues of 32 additional schools. These 60 schools contain about one-half of all State normal school students. They generally comprise the larger and presumably more flourishing schools in each State represented, and statistics compiled from them may give a somewhat flatering picture of normal school geography in the United States.

THE COURSE OF STUDY IN GEOGRAPHY

The length of the course of study in geography has been computed on the basis of 180 to 200 exercises or periods per year. Of the 60 schools three devote one-fourth to one-third of a year to geography, 15 one-half year, 30 one year, 4 one and one-half years, 6 two years, and 2 more than two years. The average course is a trifle more than one year.

In the attempt to determine the amount of emphasis laid upon the various phases of geography, the courses of study were classified as follows: (1) Physiography, including an occasional term or semester of geology; (2) commercial geography; (3) pedagogical geography; (4) general geography, comprising cases where no differentiation could be made out.

Of 50 schools giving courses in physiography, 15 devote to it one-third of a year, 14 one-half year, 13 two-thirds of a year, 7 one year, and 1 more than one year.

Of 38 schools giving courses in general geography, 4 devote to it one-fourth of a year, 12 one-third of a year, 8 one-half year. 5 two-thirds of a year, 5 one year, 3 one and one-third years, and 1 two years.

Of 16 schools giving courses in pedagogical geography, 9 devote to it from one-eighth to one-third of a year, 4 one-half year, and 3 two-thirds of a year.

Of 9 schools giving courses in commercial geography, 6 devote to it one-third of a year, 2 one-half year, and 1 two-thirds of a year.

A summation of the aggregates of each phase gives to physiography twenty-nine years, to general geography twenty-three and one-third years, to pedagogical geography six years, and to commercial geography three and two-thirds years. The combinations of these phases in different schools are too various to be classified.

EQUIPMENT

The quality of the work done in normal school courses can be inferred only from the equipment, preparation of the teacher, and other indirect indications. Of 28 schools reporting, 5 seem to have a

fair equipment of maps, globes, pictures, models, lantern slides, and specimens, 19 a good equipment, and 4 an excellent equipment. Ten have a geographical library of 100 volumes or less, 15 have from 100 to 500 volumes, and 3 have more than 500 volumes.

Very few schools possess a specially fitted geographical laboratory, but this is not essential to good work, which can be done in the class room or physical laboratory. Twenty-eight schools report some systematic laboratory work, of which 23 seem to give a fairly adequate course. Twenty-nine schools report regular field work, consisting of from three to six excursions for each class.

PREPARATION AND DUTIES OF TEACHERS

In 43 schools one or more of the instructors in geography have had special university training. While in 47 schools the teachers of geography give instruction in other subjects, in 28 of these geography is allied with some other natural science, usually physics or geology, in 5 with history, and in 14 with some less cognate subject.

CONCLUSION

Fifteen years ago geography had hardly been thought of as a natural science, and a geographical laboratory scarcely existed in dreamland. No special preparation was thought necessary for the teaching of geography, which was commonly turned over to the teacher of history or to some one whose chief interests were more remote from the subject. The work consisted largely of a study of political divisions, with some map drawing. There was seldom a suggestion that the vicinity of the school might contain geographical features worthy of attention. To one conversant with these facts the present status of geography in normal schools is encouraging. A professional school can hardly be expected to take the lead in promoting a branch of common education elsewhere neglected. As long as only three or four universities in the United States offer substantial courses in geography, teachers with university training in that subject will not be plentiful. In the common and high schools the supply of geography teachers who are as well trained as those in mathematics, languages, or history will await the demand.

While the teaching of geography in the normal schools is far from adequate, it is entering upon a new phase, in which trained teachers and scientific methods will prevail. Progress is being made, and there does not seem to be any occasion for the common schools, high schools, or universities to throw stones at the normal schools upon this score. There is a fair prospect that the demand for and supply of competent teachers of geography, both hitherto very small, may increase at a reasonable rate.

WIE KANN DER GEOGRAPHISCHE SCHULUNTERRICHT DURCH INTERNATIONALEN NACHRICHTENAUSTAUSCH GEHOBEN WERDEN?

HEINRICH FISCHER, Berlin

In allen Kulturnationen ist die Frage nach der Besserung des geographischen Schulunterrichtes aufgeworfen worden. Ich darf ihre kostbare Zeit nicht damit verbrauchen, dass ich versuchte Ihnen eine ausführliche Liste aller der Vorschläge, Versuche und Klagen zu unterbreiten, die allein in den letzten zehn Jahren in diesem Lande so gut wie in Deutschland, Österreich, England, Frankreich, Italien, Spanien, Mexiko, Dänemark, Schweden, Holland, Belgien, der Schweiz u. s. f. bekannt geworden sind. Aber es gehört zu meiner Aufgabe, die Tatsache festzustellen, dass überall, wo die Fragen einer besseren und zeitgemässeren Erziehung der Jugend auf der Tagesordnung stehen, die Besserungsbedürftigkeit des geographischen Unterrichts sich gezeigt hat.

Fragen wir nach den Ursachen, warum gerade der geographische Unterricht an den Schulen den Kennern der Verhältnisse überall nicht zu genügen scheint, so sind diese natürlich bei den einzelnen Nationen nicht völlig die gleichen. Hier ist es mehr die mangelhafte Ausbildung der Lehrer überhaupt, ihre geringe Ausdauer im Beruf, dort sind es wieder mehr die besonderen Mängel in der Ausbildung für unser Fach. Hier wieder zeigt sich ein empfindlicher Mangel an den gerade für den Erdkundeunterricht so unentbehrlichen Hilfsmitteln, dort wieder räumt man aus Vorurteil, oder aus vorgeschütztem Zeitmangel der Geographie zu wenig Platz im regelmässigen Unterrichte ein. Und was der Dinge mehr sind.

Neben diesen Verschiedenheiten im einzelnen, gibt es aber doch auch einige durchgreifende Übereinstimmungen. Sie möchte sich mit einigen weiteren Worten streifen. Sie lassen sich kurz bezeichnen als ein allgemeines Zurückbleiben der Schule hinter der Zeit. Das ist zum Teil voll begreiflich: die Schulen können nicht völlig Schritt halten mit der Entwicklung der Zeit. Der einzelne Lehrer wird mit seiner Kraft meist so völlig absorbiert von den jeweilig in der

Klasse vorliegenden Aufgaben, dass er nur unvollkommen imstande ist, dem raschen Gang des wissenschaftlichen und kulturellen Lebens unsrer Tage mit gleichbleibendem, ja wachsendem, Verständnisse—denn das letztere wäre das eigentlich wünschenswerte—zu folgen. Alle Sommerschulen, Ferienkurse und ähnliche Unternehmungen, so nützlich sie gewiss sind, können diesen Umstand nicht ganz beseitigen. Das gilt aber namentlich in unsern Tagen und für unser Fach. Es gilt in unsern Tagen, die der Welt ein noch nicht gesehenes Schauspiel stürmischer Vorwärtsbewegung der gesammten menschlichen Kultur darbieten. Es gilt für unser Fach, da diese Vorwärtsbewegung der Kultur zum grossen Teile auf ein ganz neues Verhältnis von Mensch zu Erde hinarbeitet und dieses zum grossen Teile schon durchgesetzt hat. War bis vor wenigen Jahrzehnten für den Gebildeten die Geographie einerseits ein Haufwerk von Zahlen und Namen, deren letztere man wohl mit der Lupe auf schwerentzifferbaren Karten sich suchen konnte, oder über die man allerlei historische und ästhetische Kuriositäten in dickleibigen Büchern erfahren konnte, so ist die Erdkunde heute einerseits eine lebendige Wissenschaft geworden—die Amerikaner erkennen das ja auch meist durch die Wahl eines anderen Namens an (Physiographie)—andererseits eine Sache für Jedermann. In unsrer Zeit hat das Philisterwort aus Goethes "Faust," dass der ruhige Bürger nur ein behagliches Interesse, nichts weiter daran habe, wenn hinten weit in der Türkei die Völker aufeinanderschlagen, keine Giltigkeit mehr. Unsre Erde ist klein geworden unter unsern Füssen, und wir empfinden es alle persönlich mit, wenn an irgend einer, einst entlegenen, jetzt uns nahegerückten Stelle der Erde blutige Konflikte zum Austrag kommen. Wir erleben es mit, wenn sich neue entfernte Wirtschaftsgebiete erschliessen, neue Absatzländer auftun. Die Erde als Ganzes, als ein grosses Individuum zu erfassen, der hologäische Gesichtspunkt,—um das Wort eines uns leider jüngst plötzlich entrissenen grossen deutschen Geographen zu gebrauchen, der auch diesem Lande nahestand, Friedrich Ratzels,—das ist nicht mehr eine Besonderheit dieses oder jenes einsamdenkenden Gelehrten, das ist eine Notwendigkeit für jeden Kulturmenschen.

Hiermit engverbunden ist eine zweite erst in unsern Tagen möglich gewordene Art geographischer Auffassung: das Streben das eigenartige Leben dieses grossen Individuum "Erde" in seinen wechselvollen Bedingtheiten zu ergründen: die Erscheinungen der Lufthülle, des Meeres, die langsameren Veränderungen der nur scheinbar starren Erdkruste, die Abhängigkeitsgrade und Formen des organischen und des geistigen Lebens von Himmelstrich und Boden, alles das hat sich im Grunde genommen erst der lezten Generation zu erschliessen begonnen. Mit unserer wachsenden Erkenntnis wächst aber auch unser Sinn für den ungeheuren Wert dieser Art Erkenntnis. Welche lange Kette beklagenswertester Verwüstungen hätte vermieden, wie zahl-

reiche gescheiterte Unternehmungen hätten verhütet werden können, wenn diese Erkenntnis des Zusammenhangs der irdisch bedingten Erscheinungen, oder kurz gesagt "physiographische" Bildung schon breiter und tiefer in der grossen Masse des Volkes, ja der Gebildeten, wurzelte!

Hier muss die Schule einsetzen. Denn es ist eine alte, leider zu selten befolgte Wahrheit, dass die wirkende Generation noch belehren zu wollen meist vergeblich ist; der kommenden muss man sich vergewissern.

Wie kann das geschehen? Das ist eine Frage, auf die eine eindeutige Antwort nicht gegeben, nicht erwartet werden kann. Das ändert sich nach Land, Zeit, Lehrerschaft, Schuljugend. Aber gerade weil es eine einfache Antwort nicht geben kann, sondern immer wieder von neuem gefragt und untersucht werden muss, welches die jeweilig besten Mittel und Wege sind, gerade darum scheint es mir von Wichtigkeit, dass wir gegenseitig besser als bisher über die Massnahmen uns unterrichten, die in den einzelnen Kulturnationen zur Erreichung unsrer Zwecke vorgeschlagen, oder durchgeführt werden, welche Hoffnungen man an sie knüpft, worauf man diese gründet, welchen Erfolg man erreicht hat, welche Befürchtungen noch rege, welche Enttäuschungen erfolgt sind.

Wir haben in einer Anzahl Kulturnationen schon Zeitschriften, die sich speciell mit den Fragen des geographischen Unterrichts beschäftigen: Prof. Dodge's Blatt in diesem Lande, Prof. Herbertson's Geographical Teacher in England, den Geographischen Anzeiger in Deutschland, die Zeitschrift für Schulgeographie in Österreich; und in anderen Staaten dürfte es fast überall an Zeitschriften nicht fehlen, die wenigstens zum Teil ihre Spalten den geographischen Unterrichtsfragen zur Verfügung stellen. So veröffentlichten die Annales de géographie bekanntlich die französischen Examensaufgaben, und die Rivista geografica italiana enthält sehr häufig Mitteilungen aus unserm Gebiet. Trotzdem bleibt hier nun noch eine breite Lücke. Will man sich nämlich über die Gesamtlage des Unterrichts in unserm Fache allgemein unterrichten, oder auch eine besondere Frage besser verstehen, so wird man meistens das nicht finden, was man sucht: die Veröffentlichungen sind erklärlich genug nur auf das Verständnis einheimischer Leser zugeschnitten.

Ich möchte nun vorschlagen, dass für jedes in Frage kommendes Land, oder anfangs wenigstens für eine gewisse Anzahl, ein Herr, etwa der Herausgeber der betreffenden Zeitschrift oder eine ihm nahestehende Vertrauensperson sich anheischig macht an die anderen systematisch geordnete Nachrichten über den Stand und die Entwicklung des geographischen Schulunterrichts gelangen zu lassen. Es bedarf dazu, wie Sie sehen, keiner allgemeinen Beschlussfassung unsers Kongresses, sondern nur privater Verabredung. Damit diese

aber auf einen festen Boden gelangt, würde ich vorschlagen im Laufe des nächsten Jahres, also bis September 1905, eine ganz kurzgefasste allgemeine Übersicht über die Grundlagen zu geben, auf denen sich in der betreffenden Landesschule der Erdkundeunterricht aufbaut. also die Art der Schulen, deren Unterhaltung und Beaufsichtigung, Vorbildung der Lehrer, Umfang (noch nicht Inhalt) des geographischen Unterrichts. Es würde dabei jede Besonderheit auszuschalten sein und nur eine Skizze des typischen geboten werden müssen. Ich werde für Deutschland versuchen, eine solche Skizze als Muster von dem, was mir vorschwebt zu verfassen.

Auf dieser Grundlage könnten dann die alljährlich einzuliefernden besonderen Nachrichten über Fortschritte und Rückschritte, Erwartungen u. s. w. geboten und verstanden werden.

Wie gesagt, meine Damen und Herren, es ist nur ein Vorschlag der seine Erfüllung in der privaten Verabredung einer kleinen Anzahl Beteiligter finden kann. Die moralische Unterstützung des Kongresses möchte ich aber doch nicht für ihn entbehren. Ich erlaube mir daher die nachfolgende These der Versammlung zur Beschlussfassung zu unterbreiten:

"Der VIII. Internationale Geographen-Kongress ist der Überzeugung, dass in allen Kulturnationen der geographische Schulunterricht noch hinter den Anforderungen der Zeit zurück geblieben ist. Er betrachtet einen besseren Nachrichtenaustausch als ein Mittel, um ihn auf eine den Geboten der Zeit entsprechende Höhe zu bringen."

SCHOOL GEOGRAPHY IN THE UNITED STATES

By MARTHA KRUG GENTHE, Hartford, Conn.

In the United States as well as abroad school geography is older than scientific geography. The great practical value of geographical knowledge caused the subject to be taught in the schools together with the "three R's" long before scholars thought of it as an object of their labors, and now that this country is realizing more and more what geographical science means, the progress in school geography has been undoubtedly quicker than that in any other line of geographic activity. It is to be hoped that by the time the present school generation reaches the high school and college stage conditions for mature work may have improved in proportion, so that the good foundation may not have been laid in vain.

Two causes combine to produce this apparent superiority of school geography. First, the public school work is not, or at least very little, elective; every child in the public schools is taught geography whether he cares for it or not, while in the institutions of higher learning it depends upon the student to choose or not to choose geography as part of his curriculum. Hence the percentage of students, and correspondingly of teachers, in the higher schools must always be smaller than in the lower ones, no matter how strong the course itself may be. Secondly, the conception of the name geography in the lower schools has been more and more enlarged in recent years, so that it now includes almost every conceivable object on earth, and an examination of the detailed course of study, especially during the first years, shows topics of botany, zoology, astronomy, technology, and what not as parts of geographic work. The time given to those studies being then credited to geography, they serve of course to swell the bill in its favor.

While it can not be denied that instruction in these branches is desirable and ought to be kept up, it must be requested in the interest of our science that its name should no longer be borrowed for their purposes. For this false application of the name creates the impression so often met among people otherwise very well informed, namely,

that geography is only an ill-assorted agglomeration of disconnected matter, a receptacle for all that can not be otherwise disposed of in the curriculum; and this impression more than anything else has caused the opposition still found in some places to the claims of geography as an individual science. It might be wise to avoid entirely the name geography during the work of the first years. Why not call it, for instance, object lessons, similar to the "leçons de choses" of the French schools, or the "Anschauungsunterricht" of the Germans? From that fundamental and general instruction all the various subjects combined therein would then branch off at, say, the beginning of the third year, as nature study, and manual training, and physiology, or whatever they may be called, the name geography being applied exclusively to the regular study of the countries. A great deal of confusion might be avoided by such a change.

Concerning the ways and means of instruction, it is very gratifying to note not only the excellent courses in our best schools, but the earnest efforts for improvement everywhere. One must consider what geographical teaching in this country was not so very long ago in order to appreciate the progress made within the last decade. I need not mention here the names of the ardent reformers who by their incessant efforts set the stone rolling; we are all familiar with them and look up to them in a higher or lesser degree as our own masters. But great credit must certainly be given to the teachers who, being brought up under the old routine, had to instruct not only their pupils, but themselves first of all, in the secrets of "modern" methods.

The distinctive feature of our modern school geography, like that of all modern teaching in this country, is the application, beyond the kindergarten, of the principles of Fröbel and his school. The ideas of the German reformer who found such a limited recognition in the fatherland are working in this country at present in much the same way as those of Pestalozzi were in Europe during the last century. To stimulate the self-activity of the child, to let him do and make things instead of reading or hearing about them, to base his knowledge upon observation and experience, not upon belief—this is proclaimed the keynote of modern geographical instruction in America; and so it has come to pass that the sand pan of the kindergarten and the Harvard geographical models represent only the lowest and the highest phase of one common principle.

That the use of the text-book, even in elementary schools, has not quite been done away with must be explained by a current belief—or may I say superstition?—among American teachers who think that by gathering his information from a book the child will be made mentally more independent, and who are overafraid that oral instruction by the teacher might lead the child back to the old practice of

believing instead of finding out. But this is a self-delusion. It presupposes an ability of scientific criticism which seldom, if ever, will be found with a child of public school age. The young mind, while all full of the spirit of investigation of the unknown, is always, unconsciously, on the lookout for some authority who will affirm his suppositions, and in nine cases out of ten he will accept the statements of a book, because the book to him has the weight of an authority (and it may be said, in parenthesis, that none but books which can be taken as authority ought to be placed in the hands of a school child). If he finds two conflicting opinions on a given subject, he will most generally decide in favor of the one which he supposes his teacher to hold; if he decides otherwise, we may question whether it is really a sign of independent thinking or only the love of contradiction inborn in every natural child. Therefore the frequent request of our geographic pedagogues, Let the teacher not the book be the center of the lesson, deserves the full indorsement of every one of us. Only the competent teacher, only up-to-date oral and practical instruction can gradually educate the child to think for himself. The power of independent judgment, dormant in every mind, can be awakened and developed only by careful training. If we anticipate too much, our pupils will share the fate of young Icarus. Such training, of course, requires undivided care and attention and a never-exhausted treasure of patience on the side of the teacher. It is a good deal easier to give the child a couple of books and let him have his "own" choice. But the results will show at the end of the course, when the pupils trained by personal instruction will make ever so much better high school students than those who were brought up on books.

It is the increasing recognition of this fact which has caused American teachers to supplement, and will in time lead them to supplant, the text-book by field and laboratory work, samples, models, drawings, and collateral reading. The child is no longer told that water runs downhill; he is made to see, on the slope of sand or clay in the schoolroom, that it actually does. On his molding board he can make hills and valleys, streams and ponds. Samples of the products of strange lands are open to his inspection in the school museum, and the lantern places before him pictures of countries and people far away. In the pleasant days of spring and fall study and recreation are combined in exploration of the hills and by the side of the brook.

We ought to keep in mind, however, that the laboratory method is not the only avenue to knowledge. It is just as easy to overdo in this respect as it is in book study. The exclusive application of laboratory teaching touches very closely that materialism which is not convinced unless it has seen with its own eyes, heard with its own ears, touched with its own hands. But the greatest truths will

always remain beyond demonstration, and in spite of the most conscientious efforts we should give our children only a one-sided and narrow conception of our science if we based the information exclusively upon the experience of the senses. If we consider, for instance, which of the two must be credited with a better understanding of Switzerland, the tourist who remembers that such a village had such a church, and that on the top of such and such mountain he was so many feet above sea level, or the author of "Wilhelm Tell," who never set his foot upon Swiss soil, I do not think that one of us would hesitate. Let us not neglect, therefore, by the overemphasis of object teaching, to develop also the power of mental vision in the child, to open the eyes and ears of his mind as we do those of his body. The poorer our laboratory equipment the more must we strive to make up for the deficiency by such training; and with the best of laboratories at our disposal the effort must still be the same in order to prevent the pendulum from swinging too far to that side. It is so easy to think we know because we have seen.

Unfortunately our text-books contribute to the danger by the overcrowding of their pages with illustrations often not at all done in accordance with the principle that for the child the best is just good enough. More criticism in this respect is a great desideratum. I am confident that the movement in favor of typical treatment of geography will lead also to the limitation of pictures to such as can be called typical. Yet the word typical should remain a word for the teacher only, not for the child. The type idea presupposes a knowledge of many specimens of the same kind, and to use it at the presentation of the first specimen is putting the cart before the horse. As one of the first figures in an otherwise excellent elementary geography appears, for instance, "A typical village house." What idea can a young child connect with the word "typical?" In a similar way the same book presents "A deserted farmhouse." Why not give its location, by which the child would gain at once the important fact that New England is the great country for those melancholy sights? Or "A broad street in a town." Why not say which town? "A State capitol." Why not "The State capitol of ———?" "A view of mountains and high valleys." Why not "A view of Mount Washington and the Presidential Range?" Is the author afraid of overworking the child by telling him names? A normal child of from 9 to 13 years takes to names as easily as a duck takes to water when he knows he gets credit for them; he delights in stunts of memory, and the more difficult the pronunciation the more he will enjoy them. "What is in a name?" somebody may reply. There is much more in it than the antidrudgery fiends in modern education are able to realize. It is the concrete, definite thing which interests the child; it is the mountain,

the river, the valley—not a mountain, a river, a valley, however typical—which impresses him. The reluctance to making things definite by giving their names not only leads to the neglect of a valuable opportunity to develop that important faculty of the human mind, memory—it must also be held responsible for the lack of definiteness in the capital of information with which the elementary school ought to equip its graduates. At a college entrance examination some time ago a student did not even know the name of the Grand Canyon of the Colorado. Very likely his geography had given him the picture of "A steep valley of erosion in the arid regions of the West." It is the earliest impressions which last, and therefore nobody should hesitate to make them as clear and definite as possible. The child who saw in his geography a picture of "Tremont street, Boston, Boston Common to the left," will very likely ever afterwards remember the characteristics of that impressive thoroughfare when the "paved city street, to the left a public park," will long be forgotten.

In closing I can only point to a subject which in itself would furnish material for a whole paper: I mean the deplorable quality of the majority of American maps. Even among our leading school geographers the number of those whose maps can stand comparison with corresponding products of central Europe is appallingly small. How many of them present physiographic features with at least approximate accuracy by applying some adaptation of the international color scheme? The so-called relief maps, which in fact are nothing but reproductions of photographs of relief maps, are still the exclusive favorites of the majority of teachers and authors. It shall not be denied that an actual plastic relief is a useful transition from the molding board to forms of cartographic reproduction. Even this, however, has its limitations. It can not, as far as scientific accuracy is concerned, compete with the topographic map; and this is true to a much larger extent of those "relief [a] maps" where not a single point can be located with accuracy, neither in regard to latitude and longitude, nor to height above sea level. It is all guesswork, and the fundamental problem of geography, that of location, is thereby entirely eliminated from the map.

What is worse, if brought up exclusively on these maps the children will never acquire the ability to read and interpret maps constructed upon scientific principles, never be able to avail themselves of the treasures of our governmental surveys. In a country which supplies topographic maps at a price unheard of in any other part of the world, it has been possible to make the statement that "not one person in a thousand understands a contoured map." If that is so,

[a] Mindeleff, Geographical Relief Maps. Bull. Amer. Geog. Soc., Vol. XXXII, 1900, p. 370.

the blame must be laid entirely upon the schools. In recent years a change for the better can be observed here and there. I know of several schools where the reading of the topographic map is taught in the last year's course. But this practice must become universal, and especially in the country where the topographic sheets are generally the only available local maps. How many of us, in our travels through the country, have met with any fellow-travelers trying to understand the character of the country by the aid of a topographic map?

Without underestimating the value of other helps to understanding, I feel safe in saying that a true appreciation of what geographical training means to our general education will not be realized until the use of the topographic map has become universal. Studying the work of nature by hill and brook is a good thing; studying the works of man in the different places is also a good thing; but neither of them, in itself, is geography. Geography begins only when we combine the Wheres with the Whys, as they are placed before us on the map. The too exclusive study of detail leads only too easily to the neglect of the larger perspectives of the earth sciences; the steady use of the map will serve as the best corrective. There is no doubt that as soon as we can procure first-class maps for our schools it will require only competent teachers to give us a first-class school geography in the United States.

DISCUSSION

Professor Oberhummer (Vienna) pointed out, with reference to the paper of Doctor Genthe, that the use of topographical maps seems not to be so well known and popular in America as in European countries: for in Switzerland, Austria, Germany, etc., most excellent topographical maps may be found in the hands of any excursionist. The introduction of good maps in high schools would contribute to the understanding and popularizing of the use of maps by educated people as one of the chief means of progress in geographical education. It would also seem to be of great importance that people should be able to find and buy good maps, especially the sheets of the Government survey, at the shops of booksellers, who, as yet, seem not to care at all for the sale of maps.

Professor Brigham advocated a more discriminating selection of pictures as illustrations in text-books. He supported the idea, also, of wider use of topographical maps.

COMMERCIAL GEOGRAPHY IN THE SECONDARY SCHOOL

By CHEESMAN A. HERRICK
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From the time of Carl Ritter to the present there has been an increasing recognition of the practical worth of the study of geography. This growth may be traced in the introduction of numerous forms of applied geography—e. g., political geography, historical geography, biogeography, anthropogeography, and, lastly, what is variously termed as economic or industrial and commercial geography. With each enlargement of its field geography has been of greater service to other branches of knowledge, and has itself, moreover, been enriched in content and rendered more scientific in method. A new application of the principles of their science may well claim the attention of geographers

In the pyramid which he forms for the whole of geography, Hugh Robert Mill places commercial geography at the apex and terms it a loosely formed rubble heap, the most ill-defined division of systematic geography.[a] There will be general assent to the proposition that commercial geography is difficult both of didactic definition and practical limitation. For myself, I believe that the commercial geography of the secondary school is not the place for any large introduction of new principles. Rather than a subject de novo at this period, I prefer commercial geography as a means of giving new application to old principles and of analyzing new data in accordance with laws already recognized. Thus, as modern geography culminates in the notion of the marvelous "interaction of man with his terrestrial environment," commercial geography stands as the highest development in this conception. Any attempt to start commercial geography as a new subject will break the chain of logical evolution and defeat the high ends which education should serve. It is conceived that there will be a cumulative educational effect from the continuance of a regional method of treatment and an applica-

[a] International Geography, p. 6.

tion of this method to the newer data with which commercial geography deals.

Commercial geography may keep well in the foreground one of the chief tenets of the modern geographer's creed, viz, the causal relation between man, an active agent, and an external world in which he lives; and it can show in an almost countless number of ways how man modifies his action to better utilize his environment and how he molds and shapes the environment to his own will.

No single purpose of a study can be higher than to serve as an instrument of disciplinary education. Now, while geography in general is liable to become informational and not disciplinary, commercial geography is peculiarly subject to this danger, and it is only by adopting the causal method of treatment that the danger here pointed out can be minimized. In the commercial geography of the secondary school we want not facts as facts, but those facts which are typical and representative; we want not only facts, but the interpretation of these and their proper classification under the geographical laws of which they are an illustration. This notion of commercial geography can be realized only by making it directly related to and an outgrowth of the general geography of the elementary school and the physical geography or elementary physiography in the last year of the elementary school or an early high school year.

Commercial geography, as thus suggested, should be vastly more than a " rehash " of the results of earlier study. Upon the foundations already laid can be built a superstructure that may well challenge comparison with the results from the study of other subjects. Too often the geographical work of the elementary school has been disregarded in the physical geography of the high school. On the other hand, it may fairly be claimed for the form of geography here recommended that it will hold and turn to good account a considerable part of the geographical information secured in the earlier years. Recently the writer had from an examiner the statement that those who were free from the study of physical geography in the high school were less able to pass an examination in general geography than were those from the elementary school, where geography is studied. This examiner rightly believed that the high schools should furnish geographical instruction of a more practical sort.

Commercial geography, it should be observed, is of two kinds—first, that of the special school or the school which wishes to give a special course; and, second, that which may be introduced as an element into other forms of study. Of the latter sort may be seen a large intermixture of the commercial elements with the geographical work of the elementary school, also the presenting of commercial facts in the application of physical geography, as well as the introduction of these facts in dealing with production

and exchange in inductive economics. The last report of the United States Commissioner of Education (1902) shows over 900 schools of the secondary grade and more than 20,000 students taking commercial geography as a separate subject. The number of such schools and students has risen from almost none five years ago, and we must believe that the movement of the study of commercial geography as a separate subject has but begun. If the development could be traced I fancy we should also find a marked change in the recognition of the commercial elements in the other forms of study. The facts above noted do not mean that fewer students are taking physical geography than formerly, but rather that we are teaching more geography to the same classes of students and reaching with the new subject classes of students that were not reached heretofore. Both of these tendencies may be regarded with favor.

Few subjects offer a better balancing of the practical and disciplinary in education than is possible in commercial geography. For the high school period the subject should avoid too much broad generalization on the one side and the mere encyclopedic cataloguing of facts on the other. Of all subjects this will best illustrate " man in nature, man and nature, not man alone or nature alone. "[a]

These statements are made with a consciousness that it takes time and experience to develop a subject and create its traditions. Not only is commercial geography a new subject, but by its nature it must always be in a state of change. The difficulty of the problem, however, should be a stimulus rather than a cause of discouragement.

It is the present writer's belief that a causal relation in commercial geography may be established between the following: (1) Physical features, including such facts as soil, slope, elevation, contour, outlook, hinterland, climate, etc.; (2) people, including such facts as race, government, social condition, trade policies, etc.; (3) productions, both raw and manufactured, where and how found; and (4) the trade both with the country and between it and the outside world. This suggestion will apply somewhat differently to different countries, but with modifications it can be generally applied. It is believed that better results will be secured by a regional rather than a topical method of study, and by the use of such a method many facts of the earlier geography may be retained and explained, or new facts related to the physical or political geography may be presented as they arise. It should be observed that by such a method commercial geography is geography and not a mere aggregation of economic facts.

The geography of the elementary school and the physical geography of the high school have taught the value of the geographical

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[a] Butler, Introduction to Redway's New Basis of Geography.

excursion and shown the wisdom of making home geography the point of contact in geographical study. This principle applies with equal or greater force to commercial geography. The industries and trade of the region in which the school is situated should receive special emphasis through visits to the centers of production and trade. Such excursions may become highly valuable as a training in the power of observation, and thus they will serve the end of preparing pupils for intelligent collection of commercial data. It is true that as one goes about he sees what he is looking for and learns what he is seeking—a fact well illustrated by an old sailor who had been all over the world and who knew nothing of the different cities which had been visited except the quality of whisky sold in them.

Commercial geography which is worth the name must give the power to visualize the regions of the world with their products and trade. The excursion makes this possible for the immediate locality of the school; for regions more remote there can be utilized vivid descriptions by travelers, maps and pictures, the stereoscope, and the projection lantern. If commercial data can not be quickened by these and other means, the geography of commerce will be the most inert and lifeless of studies.

No discussion of this topic could be adequate which did not consider the question of text-books. Several useful books have been prepared, and these have made possible the progress thus far attained in the study of commercial geography. But these books as a whole are far from ideal, and they have at once indicated their own limitations and made possible what we may reasonably expect—much better books in the future. If a general criticism were to be attempted against the commercial geographies now available, it might fairly be said that they are too comprehensive and too much loaded with statistical data. More of general statement, with room for class investigation and discussion, would seem the ideal. The advantages of this are twofold: Such treatment will make it possible that class books be in fact text-books, and, secondly, the treatment of the class books will not become antiquated in two or three years. As books have been prepared, work on a commercial geography is an almost thankless task, for no sooner is a text-book well established than it must be prepared over again or it will be supplanted by a newer treatment. Our text-book makers should not be too ambitious; a high school book, especially in a new field, should not be too difficult, but in making this statement let there be kept in mind another by James Bryce, that there is a world of difference between being elementary and being superficial.

Mr. Bryce has made what must be accepted as a most comprehensive statement of the purposes of the study of geography;

from this statement there can be seen the true relation of geography to other subjects. He holds geography to be the gateway of the sciences, the key to history and the basis of commerce.[a] Let geography continue to be the first two, but let us have more geography and geography of another sort in accordance with the third suggestion, but let us make sure that the form of geography termed "commercial" as taught in the secondary school shall have a sound geographical basis.

[a] Journal of Geography, Apr., 1902.

GEOGRAPHIC INFLUENCE, A FIELD FOR INVESTIGATION

By GEO. D HUBBARD, Cornell University, Ithaca, N. Y.

Historic events, business transactions, and industrial operations each have place relations and are subject to conditions embodied in their physical surroundings. This precludes no other element in the setting of the event, for there are time relations, legal relations, and several other classes of nonmaterial environmental elements which, in the present discussion, are simply waived the more clearly to see the physical stratum. As plays, ever since the drama began, have been obliged to adjust themselves to the stages upon which they have appeared, so real dramas are modified by the combined influence of the elements of the environment in which they find themselves.

Agricultural products have geographic distributions with which men can tamper but little. The Yankee who made maple sugar and cut hay in New England can do neither in the Dakotas, but must work with new crops in new ways. Only a few of the reasons for these crop distributions are fully known. Recorded observations have been taken for too short a period. Some of the differences in physical conditions are known and their relations are understood, and what is known leads us to believe that when all these conditions and relations are recognized many more of the reasons will be comprehended.

In like manner factories and transportation routes have location and distribution, determined, in part at least, by topography and the distribution of markets and raw materials.

The avowed field of geography has been the study of these conditions, these physical features, in their relations to man. Actually, however, geography has dealt with a description of the physical forms, their distribution, and, to a considerable extent, with their origins and development; but only slightly and often incidentally has any attention been given to their relations to the organic world and ultimately to man.

The effects of these directive forces, expressions of the physical environment, are summoned up in the term "geographic influence." The unity of the science of geography is in geographic influence—i. e.,

in the relation borne by the physical conditions to man, products, industries, and to the distribution of wealth, culture, and the various types of life. A definition of geography, much sought nowadays, based on this principle, will cover all that geographers want included within the science without incorporating the whole field of learning. Neither can the subject so defined be called a "hodgepodge."

A vitally important field is claimed under this unifying term, but not a new or wholly unknown one. The broad relations and their influences have been commonly recognized. Among the generalizations made, many have been faulty, because, like too much of our science work in the past, they have been based on theories and insufficient facts. The time has come for careful, systematic study, detailed research, and painstaking statement which shall be the secure foundation for future deductions. In many phases of geographic influence this need of research is apparent. The field is wide and varied. Other sciences need our results as a basis upon which to work. Better agriculture will take the place of the present when the soil survey is completed and crops are distributed on a rational scientific basis, putting each crop into that set of geographic conditions to which it is best adapted. The business man (merchant and investor) needs our results, the more intelligently to direct his buying, selling, shipping, market hunting, etc. General principles, as known a decade ago, will no longer suffice. Narrowing margins and rigid competition demand more knowledge and closer adjustment to the conditions, in order to produce the greatest crops, to make the most marketable goods at a minimum cost for materials and transportation, and to sell these goods in the best markets with least waste and expense.

We have thought that man could change everything, bend all forces to make his environment; but there is less waste of energy when he uses his environment adjusting himself and his work to it. The elements of the latter are like the rails of the track along which the locomotive moves. If the man adjusts his business, his location, his dimensions and growth to his conditions, he is in harmony with his surroundings, which, according to Herbert Spencer, is "life;" but if he jumps the track, trying to build up the wrong business in a community, grow the wrong crop, make the wrong goods, or sell in the wrong market he is at the mercy of the elements and can not hope to succeed.

Economic, industrial, and social life also must adjust to geographic conditions, and readjust when the latter change, and particularly when new conditions enter the environment. This happens in a number of ways. When a new mineral is discovered in a locality,

transformations, physical, industrial, and social, may be as great and as complete as in the beautiful, quiet, agricultural Wyoming Valley, now become the noisy, dirty, strike-disturbed Wilkesbarre-Scranton valley. When a new crop is found to be adapted to the soil, as tobacco to the soils of the Connecticut Valley, dates to parts of our arid West, or the sugar beet to parts of temperate Germany, not only industrial life responds, but commercial life, legislation, and international relations readjust.

When arid lands are opened by irrigation works, the old order passes away and a new comes in. When a trade route opens a region to the world, the response is quick and marvelous, as it has been at Harbin, a junction on the Siberian Railroad. Even medicine and war feel the influence of geographic conditions and react at their touch. This influence must be more carefully consulted if we would understand the responses, and the latter must be understood and reckoned with for the more marked success that we so much desire.

A few illustrations will show what our enlarged vision along these lines is already revealing. Differences in the climates of zones and consequent differences in life and products have long been recognized and commented upon. Recent systematic studies have disclosed most intimate relations between the plant and the elements of its habitat, soil, average temperature, rainfall and its distribution through the year, sunshine, exposure and length of no-frost period, altitude, both relative and absolute, distance from sea or lake, condition of drainage, and a number of lesser details. All this has a vital bearing on a nation's crops and products, on exports, imports, manufactures, occupations, prices, and legislation.

It is familiarly known that certain diseases belong to wet, tropical lowlands or to foul river bottoms, and that others flourish only in the winter of the Temperate Zone; but a study of the distribution of diseases and the conditions under which they occur bring to light interesting and often startling relations. Not only temperature, but rainfall and distance from water; not only the general cleanliness of the people, but even the distribution of intermediate host animals or related plants; the direction of commercial movement and the goods carried, have been, and of necessity must be, determining elements in the distribution and movement of diseases.

Some of the early geographers noted that transportation routes are established and maintained with reference to the general distribution of land and water features and carried on business between countries whose products were all different. Now it is becoming apparent that it pays in sea navigation to know the position, velocity, and direction of currents, both of water and air, if one would make the best time. It has recently been pointed out that the rounding of Cape Horn can

be safely accomplished in a certain sequence of weather conditions, dependent upon the cyclone. Very careful surveys of sea floors and lake and river beds have been made in order to ascertain just the conditions of depth, rate of filling, and character of bottom simply as an aid in commerce and travel. And on land all manner of details of relief, slope, relation to streams, and even to subterranean rock structure, are consulted, after the distribution of crops and products is known, before the railroad responds to the call of trade for an exchange route over which the crops may move.

Cities and towns usually appear at certain points because the geographic conditions are deemed favorable by the founders; but are we aware that the differentiation of towns into commercial, manufacturing, mining, or scenic centers is largely a response to the geographic conditions, both near and far, which play upon them? The growth of a town as any particular kind of a center depends in great measure upon its physical environment. Even changes in the city's rate of growth or in its importance are often brought about by changes in the geographic conditions or by new adaptations to former conditions. Indianapolis, the capital of Indiana, was located arbitrarily, when a capital was needed, in the center of the State. It had no waterways worthy of note, no mines or quarries, no scenery to attract, and no springs or specially healthful conditions. It was on an open plain, and there was no reason why any two trade routes should converge there, or even why one should deign to pass through the town rather than anywhere else on the plain. But the plain was found to be a rich agricultural region. Farm products for other localities collected in Indianapolis and import goods came here for local distribution. Hence a road was built to the town. Then the plain was taken advantage of, and roads were made to gather in from all quarters because there were no barriers in any direction. The open plain gave every opportunity, and Indiana's capital has become the greatest purely railroad center in the United States, besides being a prominent industrial center.

Army officials from remote antiquity have used geographic routes as highways, and have contested the richest lands; but the modern general must take advantage of all details of relief, distribution of stream, swamp, and lake, and must know all possible, though unused, natural roadways, in order to preserve and maintain his front, change or reenforce his line, or prepare for a successful retreat. Moreover, if he can decoy the enemy into unfavorable geographic conditions so much the better. The leader best acquainted with his local geography has advantages for movement, defense, attack, and the getting of supplies.

These closer studies are showing in a large majority of the cases

analyzed that each city, town, fort, battlefield, highway, and railroad fits down with remarkable precision upon its physical environment, responding in a score of details to the influence of the latter. The principles underlying these relations are just beginning to appeal to us. They constitute a growing "tip" on the science—the terminal bud. Pioneer geographic exploration is drawing to a close, while research in geographic influence is just beginning and promises great rewards to science, revelations in social and industrial economics, and millions for commercial and industrial enterprise.

PHYSIOGRAPHY IN THE UNIVERSITY

By C. F. MARBUT, Columbia, Mo.

Physiography in this paper means morphology of the land. This is confessedly a narrow limitation of the subject, but within the time and space allowed I shall be able to discuss only this phase of the general subject. The discussion will relate chiefly to undergraduate work in the university, and to work also that may be elected by the average freshman.

Under existing conditions freshmen enter the university with very little special training for physiographic work. Some of them may have taken courses in physical geography in the high school, but in many cases they receive very little training for further work in physiography as a science. Even where the New Physical Geography is taught, and where the latest text-books are used, the work is too often theoretical rather than scientific, developing a tendency toward attempted explanation of phenomena by deductive rather than by inductive means.

Physiography, or the study of land form, is a natural-history subject—one of the members of a large group of subjects closely related in character. In order to attain the best results from the study of any one of them, it should be studied by the methods that have been shown to be best adapted to the members of the group as a whole. Physiography, as the youngest member of the group and the latest to claim recognition as a subject of educational and disciplinary value, should look to its older sisters for suggestions.

The study of land form is as wholly a matter of observation as is that of a grasshopper, crayfish, or frog. In each the facts of form and structure, the relation of parts, and progressive change are the things that are subject to observation. In each the results of study are the same—well-developed habits of observation, training in the grouping and comparing of facts, and the drawing of conclusions based wholly on the facts.

The objects sought and the methods of attaining them are of the same kind in physiography as in biology. Animals are studied in the

laboratory, especially by freshmen, with the object of determining the facts, not to illustrate a theory. Land form also should be studied at first merely as fact. Its details must be seen, recorded, grouped, and compared just as facts are treated in the biological laboratory. In the study of an animal in the laboratory, however, merely looking at the animal is not considered sufficient. Mere sense of sight must be enforced by drawings, the proper execution of which will demand the closest scrutiny of the eyes as well as of the mind. The object is pictured as a whole as well as dissected and then pictured in parts. It is only by such picturing on paper that clear picturing on the mind is effected. Land form, to be conscientiously studied, must be treated in as nearly the same way as the nature of the case will allow. Mere observation, or rather, mere seeing, is less effective in this study than in biology, because of the size of the object of study. No land surface can be studied on the ground, by an unskilled physiographer, in such a way as to arrive at any definite conclusion as to its essential features and their relation to each other except through the medium of drawings. In other words, a land area, in order to be studied thoroughly, must be mapped. Class excursions for university students, in which careful mapping of the area traversed is not rigidly required, have relatively little physiographic value. Even if the excursion is followed by a written report by the student, the result is slight because of lack of any necessary connection between close and accurate observation and a general written description. For public school pupils the excursion is valuable because the teacher is able to illustrate by this means geographic terminology, but the university student has long since passed that stage and must see the relations of facts as well as the isolated facts.

Accuracy and minuteness of observation are attained only when the facts are recorded. In physiography facts are best recorded in a map. It is only after facts have been fully and consciously seen that they can be recorded in a map. Without the mapping observation will be less sharp. The ability to see land form clearly is attained only through some training in map making. Observing and recording therefore have a reciprocal relation.

The study of one land surface, however, such as may lie within the reach of any university town, can not fulfill the requirements of a well-balanced and complete course of study in physiography any more than can the study of a crayfish fulfill the requirements of a course of study in biology. A crayfish represents only one of the groups of animal forms. Any one land area of such size that it may be reached and studied as a part of the work of a university course of study will rarely represent more than one group of land forms. The study of one area on the ground, however, will furnish a founda-

tion of fact and experience for the study of other forms by means of maps in the laboratory.

The study of additional and different land forms in the laboratory can not run parallel to the study of additional animal forms. The latter may be brought into the laboratory and studied in the same way as the first type. No change in methods of study is necessary. Land forms can not be brought into the laboratory. A great number of different forms can not be studied on the ground because of the practical impossibility of reaching them; neither can they be transported to the laboratory.

The only practicable thing to do is to study an image, and since it must be brought into the laboratory it must necessarily be a reduced image. There is, however, an additional reason for studying a reduced image. Even the study of a land area on the ground, without the use of a reduced image for continual reference, fails to attain the best results because of the impossibility of seeing any considerable area at one time. General views which are as important as detailed examination can not be obtained on the ground because of the size of the object being studied. The ability to see all the parts of a considerable land area in their true proportions and relations from studies of the individual parts is attained only by the skilled physiographer. The average freshman does not possess it at all or possesses it to a very limited degree.

The size of the object of physiographic study makes it necessary to study it through the medium of a reduced image, either partly or wholly.

The biologist encounters a difficulty of just the opposite character. He must examine enlarged images of some of the objects which he studies.

The most perfect image is a model, or, in a less degree, a relief map, but it is impossible at the present time to study any large part of the earth's surface by such means, simply because they can not be obtained. Only a few small areas scattered over the earth's surface have been even imperfectly reproduced in this way. For the study of the morphology of the lands of the globe they are of practically no value. They may, however, be used to illustrate lectures on physiographic principles or the theories of land-form development.

For the study of more than a small number of isolated areas recourse must be had to large-scale topographic maps. Of these there is an abundance, as every teacher of physiography knows. Practically the whole of western Europe and considerable parts of North America are represented by such maps. They are and will continue to be for a long time to come the chief reliance of the teacher of physiography. From such maps the student and teacher must get their foundation of facts. The getting and classifying

of the facts constitute a large part of the work of the undergraduate student in physiography. Before land forms can be interpreted and before geographic processes can be fully understood and realized as actual things a considerable body of fact must be accumulated. Out of these the theory of land-form development must be built up. Even if the student divorces his facts from his theory entirely at first, which is not what is meant here, the later discussion of the theory will be more intelligible because of the ability to test it with the facts. The scientific study of an object consists in the determination, first, of the facts. For the proper interpretation of process and development a greater body of fact is necessary in physiography than in biology. In the latter process may be studied by observing what is happening from hour to hour or day to day. In physiography processes act too slowly for such methods; so they must be got at by the comparison and correlation of facts.

We must, however, in university work go beyond mere fact to its interpretation. Land form must be seen as the product of forces acting through time on certain more or less fixed conditions in the earth's crust. That phase of the earth's crust of most importance in land morphology is its structure or anatomy. The relations of anatomy and morphology in the earth are as close as in an organic being. In this as in other phases of earth study we are either limited to a small area or else forced to obtain our facts from maps. From these, in the form of geological maps, there is abundant opportunity to obtain the main facts of earth anatomy over large areas. A large collection of geological maps is as essential a part of the equipment of a physiographic laboratory as is that of topographic maps.

In the study of such a map for physiographic purposes no previous knowledge of geology need be required of the student who is beginning his physiographic work. In fact, a certain amount of training in descriptive geometry is of more value than training in laboratory paleontology or mineralogy. The student may not even know the names of the common rocks, though in the great majority of cases he will know at least that much. The student of average ability will learn to read a geological map in a few days. He must have the table of geological formations at his fingers' ends, and know the relative position and age of each.

If the map, either topographic or geologic, be published in sections covering small areas, the sections must be mounted in the form of wall maps as large as can be conveniently handled. The larger the better, because of the better general view obtainable from such maps. The broad relation of the various parts can be seen no better when represented on separate sections of a map than when seen by

bits on the ground. In many cases the broad relations of land forms are of more importance than minute details.

Next in importance to a large collection of large-scale topographic and geological maps is a large collection of selected photographs. Mere pictures, excepting in public school work, have very little if any value when used merely as such. When well selected and properly used, they occupy a place that can not be filled from any other source.

Models, maps, and photographs constitute the equipment for good laboratory work in land morphology during the undergraduate life of the student.

There are two ways to use this equipment in teaching land morphology, the way selected depending upon the point of view taken by the professor. It may be used to illustrate a series of lectures on the theory of land-form development, or it may be used, under the direction of the teacher, as a means by which the student may be taught to draw his own conclusions on such development by the study of the facts of form shown on the maps. In the first case the laboratory is merely an accessory to the lecture room, and the material of the laboratory is merely illustrative material and used incidentally. In the latter case the relations of lecture room and laboratory are reversed. The laboratory is the place where the work is done. It is the place in which facts are collected and manufactured into finished products—where all hypotheses are put to the test of facts.

The latter is the more scientific. It is the method followed in the other natural history sciences—one that has demonstrated its value as a means of educational discipline during the last half century.

A serious difficulty in the study of physiography by the laboratory method at the present time is the lack of a laboratory manual or guide for the student. The biologist has a great number of guides to select from. The lack of this essential in physiography is due partly to the newness of the subject in the university curriculum and partly to a lack of any tradition as to what should be included in the subject. There is no general agreement among physiographers as to what the term means or what university work in the subject should include, nor the method to be pursued in lecture room or laboratory. Until this condition becomes established the teaching of the subject will be difficult. Although no manual can be purchased yet the student in freshman and sophomore work at least and preferably in junior work must have one. It must be supplied by the teacher. The best manual is not one that discusses the land forms being studied, but one that consists merely of a series of questions or suggestions so drawn that they can be answered only by close and careful, almost microscopic, study of the material. They must be so drawn also that the significant and essential features of the region are brought out

clearly. The questions or suggestions must be direct and to the point. General suggestions will not answer the purpose. The student should be required to get his facts from the laboratory material, not from such descriptive literature as may exist for the area concerned. An experience of several years has convinced me that undergraduate students will not as a rule obtain satisfactory results by putting the material before them with general directions for work. The photographs should be studied as closely as the maps. Each photograph should be numbered and the point from which the view was taken as well as the direction and range of view located exactly on the large-scale topographic map. The map and photograph should then be studied together, every significant object in the view located on the map and vice-versa, so that the correlation of the two is complete. This can be accomplished only by a set of questions drawn for each photograph. Probably a better mental conception of the significant facts of form in an area well covered by good geological and topographic maps and by properly selected photographs can be obtained by the study of such material than could be obtained by the student on the ground even with the use of the maps, but without the photographs.

The average student, however, looks upon a photograph merely as a picture, unless his attention is specifically directed to what it shows. Merely looking at photographs is not laboratory study.

Geographic or physiographic literature is concerned to a great extent with the development of land form or with the explanation of the facts presented in particular areas. It can not in the nature of the case give as clear a conception of the facts as can be obtained by study either on the ground or of a good map. Before explanation of facts can become intelligible the facts themselves must be observed. Only after a certain body of fact has been worked out for a particular region can the student get the greatest benefit from the literature. He must not even then be allowed to use this outside the laboratory. He must have the maps and other laboratory material at his command while reading. Geographic reading without frequent reference to the maps is of very little value.

There is very little literature that can be placed in the hands of any but advanced students in physiography, because most of our literature on physiography is buried in technical papers on geology. There are, however, a small number of papers that may be profitably placed in the hands of students after the facts of the region discussed have been worked out from the laboratory material. Such papers as Grabau's or Gilbert's papers on "Niagara;" Davis's papers on "The Outline of Cape Cod," "The Seine, the Meuse, and the Moselle," "The Drainage of Cuestas;" Buckman's paper on "The Development of the Severn;" Mills's paper on "A Portion of Sussex;"

some of Fairchild's and Leverett's papers; the descriptive numbers of the National Geographic Monographs, and a few others. All of the papers named are descriptive mainly—not theoretic.

The part taken by lectures in the undergraduate work in phyisography should be made subordinate to laboratory work and recitations or quizes on the laboratory work. Whatever the relation of lectures to the other work in other sciences may be, in physiography it should be as stated. For undergraduate students there is very little real discipline in listening to lectures, however valuable they may be. There is too much temptation to theoretical generalization on an insufficient basis. The average undergraduate is very much inclined to that sort of thing when he reaches the university. This is especially true with regard to physical geography. Very careful treatment of such a man is necessary if any work is got out of him.

The time of the teacher should be taken up in directing and assisting rather than in leading.

The study of the facts should be taken up from the areal rather than the subjective point of view, i. e., the regional ideas should be the controlling one. This does not mean that all parts of a region should be studied with equal detail. Special areas which illustrate certain physiographic features particularly well should receive the greatest amount of attention and the rest of the area studied by the comparative method. The areal study is important in physiography because of the practical, as well as educational, value of the subject. If training alone were all that could be obtained by the physiographic study, then the study of the subject through a few types would be permissible. The facts of physiography, however, are of such great value in other lines of educational and practical effort that this phase of the subject can not be neglected. In a practical age and a country where the first question asked of any proposition is "What is there in it?" this phase of the subject will appeal to students when no other will.

The work should take up, for example, the physiography of the United States, studying the whole area with as much care as the nature of the case and the data obtainable will allow. Such a course of study will occupy the time of an ordinary six-hour course of study through one semester or one of three hours through two semesters of the university course. This may be followed by a three-hour one-semester course on the physiography of Europe and a course of lectures on the broad phases and world relations of earth form and the theory of physiographic development for another semester.

The student who does not intend to become a specialist in physiography will probably go no further in the subject than this. He may, however, take a semester course in meteorology or climatology.

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EXCURSIONS IN COLLEGE GEOGRAPHY

By WILLIAM HARMON NORTON, Professor of Geology, Cornell College, Iowa

The excursion in geography is based on two fundamental principles of education. It has long been recognized that first-hand knowledge must form the foundation on which all other knowledge of a subject is to rest. Nor is it questioned that in higher education training in research is more than information. Learning is not enough to make the scientific scholar; he must be trained to observe, to arrange, to compare, to draw inductions, to propose hypotheses and test them, to solve the problems of his science.

If the application of these principles has been less thorough in geography and geology than in other sciences, it is only because of the difficulties inherent in our subjects. The phenomena with which we deal are for the most part too large to be brought to the laboratory for observation and experiment. If we study them first hand and with the technique of research it must be in the field. The excursion, therefore, in the earth sciences has the same place as the laboratory has in other studies; it gives first-hand knowledge and definite and accurate conceptions of reality; it teaches the methods of investigation. The field has a smaller place in teaching geography than the laboratory has in other sciences, but this is not because its value is underrated, but only because it is less manageable than the laboratory as an educational instrument.

The excursion is laboratory work outdoors, and it meets, therefore, with climatic difficulties. In latitudes of severe winters it is suspended during much of the college year. Our schedules must be arranged—perhaps I should say disarranged—so as to bring the topics where field work is most needed at the beginning or at the end of the year's courses. Excursions thus crowded into a few months of fall and spring are restricted further by the weather, and how serious this restriction may be those teachers know who have experienced a May or an October of rainy Saturdays. The uncertainty of the weather makes it difficult to arrange our programmes in advance, and the field meet designed to introduce or to illustrate

a given subject may needs be postponed until it has lost its pertinence or be given up altogether.

Nor is it easy to avoid conflicts with the other engagements of our students. In most schools the excursion is not assigned definite place on the college roster, and the regularly scheduled exercises of each day hold the right of way against it. The excursion can not be limited to the hour or two allotted to other college exercises, but requires often half a day at least. Conflicts are therefore numerous where it must be foregone in favor of recitations or other scheduled exercises. It is thus usually deferred until the Saturday holiday, where it competes with athletic sports, and unduly lengthens the working week both of student and instructor. In some schools the large force of instruction with the employment of student assistants permits an excursion to be scheduled on the college roster for four afternoons a week, and the student registers for field work on that afternoon in which his time is free. Such a delightful comity prevails in several American universities that students are excused—"cheerfully excused," one correspondent writes me—by their departments for absence on excursions, though of course the work is to be made up later. But I see no general relief from these conflicts until the excursion comes to be considered as a college sport instead of an essential part of scientific education. When the field day in geography is once placed on the same plane with football our students can be taken by the day and week hundreds of miles away and excused from all their classes meanwhile.

Certain difficulties are more or less inherent in the excursion. The number participating may make it impossible to give close supervision and direction to the individual student. Our young people, exhilarated by their unaccustomed release from sedentary tasks, tend at first to look upon the excursion as an outing and to take an attitude of mind more suited to a picnic than to serious study. As the field meet is held more often and as students are sent out in small parties, each in charge of an assistant, such difficulties diminish and they practically disappear with thoroughly interested students and those in advanced courses. To meet these difficulties, however, requires all the qualities of the successful class room and laboratory instructor raised to the *n*th power. The important problems must be set clear in view, investigation must be directed, and the attention of the class is to be held under circumstances which can not fail to be distracting. To make the exercise to all who take part in it one of earnest intellectual effort without impairing its natural pleasure, taxes a teacher's skill, if not his patience, and requires a thorough knowledge of the local field, studied preparation of methods, and experience in this kind of work.

So various are the subjects studied in the field and the purposes in

view that even in elementary courses no uniform methods are adopted. Any formal lecture is certainly out of place. A short demonstration may be useful, especially in closing the exercise, or such a review may be postponed to the recitation hour, when the students' papers on the excursion are presented.

In general, the end of the excursion is best met by whatever method rouses the student's interest and effort and leads him to describe accurately what he sees and to think out clearly the causes of it for himself. That field work has the greatest zest, I think, to which the student brings for solution problems which have already risen in the lecture room and laboratory. He holds in mind various hypotheses by which the facts might be explained, together with the critical phenomena which would decide in favor of one hypothesis or another, and his search for these decisive evidences can hardly fail to be diligent and fruitful.

In many cases problems can not well be brought before the student until the field is reached, but here also they may be set forth with advantage early in the exercise rather than at its close. Facts which might seem trivial so long as they were unrelated details of observation gain dignity when they are seen to lead up to large conclusions. Thus in the study of the not uncommon sections in the Middle West of the United States, where deeply decayed rock mantled with residual clays or geest is overlain with till, the question whether the rock decay is older or younger than the deposit of the till may be raised as soon as the general relations of the section are well seen. With this problen in view the discovery of fragments of geest kneaded in the till becomes to the student one of the first importance, proving the geest pre-Glacial and that a continental glacier may, under certain conditions, move over rotten rock and its residual clays and leave them disturbed but little.

Some topics may best be opened in the field without the preparation of any previous study. Investigation of a section of the drift may well begin class work on glaciers. The characteristics of the loess are better learned outdoors than from any text-book. Care is needed to advance no step beyond the facts open to observation and the inferences which may be drawn clearly from them. Least of all in the field is there place for the dictum, thus saith the authority. If questions rise to which the facts before us give no answer, let them go unanswered for a while and trust to an awakened curiosity to continue the search.

The active investigative attitude of mind is to be encouraged, not the passive attitude, the listening ear. Individual effort is stimulated by requiring of each student a formal report of his work. His field notes are written fully on the spot. With beginners suggestive

questions are needed at every step, and before any subject is left some notes may well be read aloud for correction and addition by the class while the appeal in case of disagreement can yet be made to the facts before them. Sketches, maps, and diagrams are prepared, and may be inspected also as far as possible, on the spot. Some pains are taken by the instructor to have the reports conform to the rules of scientific writing. The uninitiated are warned to avoid all that is subjective in thought and language, to omit references to the weather, the route and incidents of the trip, and to describe in simple phrases the things which they have studied, stating logically the inferences which they have drawn.

Even in elementary courses considerable is taught of the use of instruments—the compass, the hand level, the aneroid, and the clinometer. Distances are paced, dimensions and angles of slope are estimated by the eye as well as measured afterwards. Angles of slopes will always be found to be overestimated, and occasionally an estimate of height may be found no closer than that of the high school graduate, who guessed the height of the Egyptian obelisk in Central Park, New York City, at 1,000 feet. Contour mapping is practiced in the field and the data taken for the preparation of geological maps and sections.

In more advanced courses, study, mapping, and technical description are made more systematic. Small areas are mapped with the plane table. Students are given special areas to work out independently, and their final reports rise to the dignity of theses.

There is one general preparation for the excursion which, I am convinced, is greatly needed. If our students do not "tackle" well the problems of the field, it is probably not only because of their inexperience in outdoor study, but also because they are unaccustomed to solve problems in the class room. Lectures, library references, and text-book recitations do not encourage the investigative attitude of mind. The departure most needed in our text-books and our teaching is the wider, freer use of problems whose function in our inductive science is that of the exercises of inventional geometry. If, for example, the means of discriminating contemporaneous lava flows from sills have been worked out in class room and laboratory exercises, one of the best possible preparations has been made for an excursion to some of the outcrops of the traps of the Newark system of the Connecticut Valley or of northern New Jersey, often visited by students.

The scope of the excursion is limited. The field accessible to the most favorably located school is far from embracing all the phenomena of earth science. Few topics can be studied in the field, nor need any topic be studied there alone. But if the excursion secures even a little first-hand knowledge that leaven will permeate and vivify

the entire body of knowledge of our science. A little field study of land forms, sufficient to make the subject real, to develop the topographic sense, to give some few type specimens for reference, to bring into clear view the slow, sure workings of earth forces in the present and in ages past, to train in methods of research—even a little field work will lay the foundation on which the superstructure may be raised by other means.

Models and photographs are only a step removed from nature. To study a good model, such as that by Howell, of the Chattanooga district, might almost be called an exercise in field geography. The photograph, projected by the lantern, of the glacier, the sea cliff, the lava flow, the desert dunes, or the dissected peneplain gives almost the sense of reality of the view of the thing itself, and is to be studied by methods much the same as those of the excursion—as phenomena to be described presenting problems for solution. When contour mapping has been well learned in the field, topographic maps and charts open up the land forms of much of the world to laboratory study.

Every college teacher knows how greatly the excursion is still needed, even in its elementary exercises. Our students have not seen things nor have they learned to see things. Only a small per cent of college students, at least in the Western States, have done field work in secondary schools. The attention of most of our students has never been called to the phenomena of our science. Of course they have not seen them any more than they have seen the structures of leaves and flowers unless they have studied such in botany. The training which students have received in other studies is not our training and can not take its place. As one's memory for faces is not strengthened by committing vocabularies, so a critical observation of Greek accents or of organic tissues under the microscope does not make the student ready to read the lessons of the sky line and the profiles of hills and valleys. On the whole the conceptions of the college student in our science as he comes to us are faint and hazy—undertimed, underexposed, and unfixed negatives—and are derived largely from words and not from things. His education has been largely bookish. The study of nature in the field throws the average student into a new element where the support of authority is wanting, and he is decidedly uncomfortable until he has learned to swim. Our students crowd about the instructor to obtain, if possible, some authoritative word for their field notes far more eagerly than they turn to investigate a section for themselves. The conception derived from books of what they ought to see blurs the impression on the retina of the thing itself. Thus students standing in the dry channel of a little brook have told me that the pebbles were well water worn

and rounded, while in fact they were subangular stones washed from the adjacent bank or drift. The university student who cried out, "But, Professor, where is the volcano which threw out all this stuff?" when she was on a field meet at an outcrop of Ordovician shale, packed with fossils, flat lying, and hardly altered from the sea mud it once was, is an exceptional case, but I assume that she must have been studying volcanoes at the time.

From communications from many American colleges and universities, giving in detail the field work done in earth science, I am assured that the excursion holds an increasingly large and valued place. In a number of elementary courses outdoor laboratory work counts one-third. In general, our best higher schools can say, in the words of one of my correspondents, "We have all the excursions we can get in."

It is in the university summer school, or summer quarter, where the students' entire time is at command, that the excursion has developed to its best. Field courses are offered by a number of American schools, in which small parties of advanced students spend five weeks or more of the summer in camp in the serious study of some area. Among the regions where such investigations were in progress in the summer of 1904 were eastern New York, central Wisconsin, the Lake Superior region, the valley of the Mississippi bordering Illinois, the Black Hills, the Bighorn Mountains, the Colorado Rockies, the Great Basin ranges of Nevada, the Grand Canyon of the Colorado River, and the Hawaiian Islands. An equally thorough training for the cadets of our science is afforded, whereas at least in four States of the Union the State geological survey is so closely connected with a university that capable students are employed on the field work of the survey during the summer vacation. It is from these university field courses and from work on the geological surveys of the States, the United States, and Canada that American geographers are now graduated.

PHYSICAL GEOGRAPHY IN HIGH SCHOOLS

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Physical geography, though in one sense as old as the hills themselves, has been looked upon and is still considered a comparatively new subject. It has a brief past, a period which was not formative and preparatory, but which rather represented a cycle of inactivity preceding renewed activity or revival. At present we are in the midst of a period—also brief—characterized by activity and accomplishment, such as should be characteristic of the youth of any life; characterized also undoubtedly by some of the mistakes which necessarily accompany experiment. Toward its future we are now looking forward, to be characterized, we hope, by increased activity and accomplishment, by steadiness and stability also. It is my purpose in the following paper to give, very briefly, an account of the past, the present, and of what we hope for in the future of physical geography in the high schools of our country. Twenty years ago physical geography was a subject which appeared in the curriculum of public and private schools as one to be pursued for a term of from sixteen to twenty weeks, if so elected by the pupils themselves. These pupils had passed through the preliminary steps of political geography in the grammar schools, where the emphasis had probably been laid upon arbitrary memory efforts in the study of political and natural features, and now found themselves confronted with new and more difficult problems in their high school geography.

To the standard text-book of that time, Guyot's, the modern physical geography owes much; and to it also, I believe, many of the more mature students and teachers of physical geography trace their first interest in the subject and their first inspiration along such lines. Concise, interesting, vivid, giving cause and effect their due share in the treatment of the successive problems of physical geography, those of us who studied or taught it still find its very language coming often to our lips, making a ready tool for rapid work. Other books most frequently used two decades ago were Warren's and Maury's. These books were all similar in style—in outer form the type geography of

our childhood; within, the subject-matter was arranged in double columns of alternating coarse and fine print, with no attempt at illustration. They were much less attractive to the eye than our newer books. The problems, which when strictly classified we designate as meteorological, were less empirical than those of physical geography proper. Here, however, explanation was not omitted; on the contrary, much more difficult explanations were given than are now attempted. It was not upon the text-books, then, that the burden of responsibility for the unsatisfactory condition of the subject in schools rested. This was divided between the school authorities who gave the subject no consideration, and the teachers who, chosen for convenience sake, were often wholly unfitted for the work.

As a result of this low standing of the subject, and the low standards set for the teacher, the presentation naturally lacked much that we now consider essential. The method was purely a text-book method. Each topic was presented as a complete unit—a chapter to be opened, committed, and finished with little reference to the preceding or to the future topics—cause and consequence were but little dwelt upon, and the laboratory method was practically unheard of. Notwithstanding the adverse conditions under which it labored, physical geography was considered an interesting study from the very character of the subject-matter. The whole thing lacked vitality—lacked reality. It was presented as a series of spectacles, the most sensational being most emphasized and longest remembered. Too much emphasis was laid upon externals—too little upon structure, process, and gradual change. The idea of the impermanence of the everlasting hills was scarcely grasped and the classification of land forms according to their phase of development was not attempted. Systematic botany and zoology were at their zenith, but classification in geography was almost purely arbitrary and based upon externals. Only great teachers recognized any other. Outdoor observations were purely accidental or incidental at the best, and there was only the most casual connection between the actual outdoors and the mountains and hills, the rivers and valleys of the book. Definitions were much insisted upon and partook of the general empirical character of the teaching. They were most arbitrary and quite satisfactory if one could accept them.

The aim of the teaching of physical geography was a somewhat shifting one, in keeping with its transitory position in the course. It could hardly have been called a culture subject, nor was it as disciplinary as some of the other sciences of the schools. It was too often a stop-gap or a makeshift, and its results tallied closely with the skill and effort put into the work of preparation and teaching.

During the last fifteen years, or perhaps more accurately speaking during the last ten years, physical geography has made great pro-

gress in popularity. It is now taught in nearly all good city schools, and appears on the curriculum in many of the smaller schools of New England and New York, while the Central West is undoubtedly more progressive in this respect than is the East. Its popularity among pupils has increased also with its wider field and with the improved methods and facilities for teaching. Its appeal to pupils, whether of mature or immature minds, is unquestioned.

Its position in the school course is a varying one, but it is a much more secure one than formerly. Ordinarily it is offered as an elective, in some schools to the first-year pupils, in others to those of the second year, while in others it is taught as a more advanced subject to the juniors and seniors, or, again, it may be given early in the course and then reviewed and enlarged upon later in preparation for college. There is something to be said in favor of each of these methods even from a disinterested standpoint, and in view of the needs and requirements of each individual school there is much to be said as a reason for putting it either in the first, second, or third year. In a year's study of physical geography, whether it be early or late in the course, we find it practicable to study type land forms, to describe them, follow their history, classify them, learn something of their human value, and, finally, to apply the type to other lands. We study briefly the ocean with its main features and motions, and lastly the atmosphere and its phenomena. This study is, of course, all elementary, and yet the results attained compare very favorably with those in more advanced classes; they are encouraging and very real. It enables the pupils to interpret what they have already seen; it opens their eyes and their minds to much that they have never seen; it arouses a questioning attitude and a new alertness; it makes travel doubly interesting, and it is not easily forgotten. I have put elementary meteorology last in order as I do in teaching, but it is by no means last in importance or interest and should be included in every course in physical geography, no matter how elementary.

Within the last ten years also new text-books have been published which mark a new epoch in the teaching of physical geography. Put forth by men of acknowledged attainments and leadership, the best ones among them bear the hall-mark of authority. Attractive in form, scientific, and accurate, and increasingly practical, our present-day text-book in physical geography marks the most rapid advance in value and the quality of teachableness. The very nomenclature of the modern text-book is in itself an indication of the difference between the new and the old in physical geography. Doctor Crothers has said in a recent essay that a noun is known by the adjectives it keeps, and this is quite as true in physical geography as in literature. A young river or a drowned river, a young or a subdued mountain,

at once conveys a picture to the present-day student of physical geography. But a few years ago such nouns did not keep company with such adjectives, and the terms would have been quite unintelligible even to students of the subject. Cuesta and peneplain are new nouns which convey their own meaning without associating adjectives. Progress has been made also in supplementary material to which pupils may be sent as to original sources. This is in the form of monographs on geographical subjects and State and town geographies or geologies, all of them too few in number considering their excellence.

Under the guidance of some of the more recent of our best text-books physical geography must be taught as a laboratory subject, and is at once taken out of the realm of the abstract and the empirical. Laboratory work and laboratory equipment have made less rapid advance than text-books, and along this line there is the most inviting field for progressive work. Fieldwork as a branch of laboratory work also offers most promising opportunities for the activity of original minds.

In the presentation of a subject which has the status of physical geography in the high schools of to-day the teacher is a most important element. This is undoubtedly true always, but less strikingly so in subjects where lines of work are already very definitely laid out. The work of physical geography demands a teacher technically trained, progressive, judicious in experiment, enthusiastic, and open-minded.

With the emphasis now laid upon professional training, the increasing demand for technical preparation, and increased opportunities for preparation along special lines, the number of teachers specially prepared for this subject is increasing, and with this improvement in the teaching force the quality of work done has also improved. In the more advanced schools a college course, years of special study of the subject, or summer study at home or abroad now fit the teacher of physical geography.

Both the impulse toward better work on the part of the teacher and the opportunities for doing better work have come from above rather than below, because to our leading colleges, and oftentimes to single individuals in those colleges, do we owe both inspiration and opportunity. Harvard, Yale, Chicago, and Columbia, and an increasing number of other colleges now give courses in geography which are most valuable to teachers and advanced students, while the summer schools offer opportunities for brief but intensive work to the larger number who can not avail themselves of the full college courses. To college professors also we owe our text-books and in large measure our present tendency toward laboratory work.

If in all or most of our high schools these things were true—that

there was laboratory equipment for physical geography; that it occupied an acknowledged place in the school course; that abundant time was given to it; that the text-book was scientific and satisfactory, and the whole subject in the hands of a competent teacher—then we might say that physical geography had indeed made great strides. These things are true in many schools, and increasingly true each year, but the fact remains that there are also many schools—some of them among the largest and best equipped—where methods of teaching prevail which are more representative of the past than of the present, a condition of things which is simply the result of the plan of school administration. In such schools insufficient time is given to the subject; it is frequently introduced in the school course to serve a temporary exigency; no trained teacher is provided, and in some cases no text-book. This, however, is not a permanent condition. It simply means that the whole subject is in a transitional stage. A lecture course in a high school or a brief course based wholly on the book is merely a beginning, which must soon, of necessity, lead to better things. The conditions now are very hopeful, and I feel almost inclined to say that those who shape the work in phyical geography at the present day hold the schools in the hollow of their hands. College preparatory high schools, where the traditions are most strongly classical, have introduced and are introducing physical geography as a subject opening a comparatively new and hopeful field. Schools which offer a general course for the sake of numbers of pupils who finish their school career with the high school have introduced it or are ready to do so, as a practical subject suited to the needs of many pupils. Schools which attempt to do both these things must of necessity make it a part of their work, and the manual training schools also. There is a very wholesome attitude of mind among people in general toward outdoor subjects, an attitude, too, which demands a certain vitality in our treatment of outdoor things—a breadth and strength and largeness, such as can well be used when one studies the big things of nature.

The course of the high school itself is in a somewhat unsettled stage—old traditions are giving way and much that is new is being added. The work in the new geography, so called, has been notable for its individuality, if I may so term it. One man in a college here and there has sent out teachers who, acting on the inspiration thus received, have carried the work to widely separated schools. This work has been individual, not only in the sense of large dependence upon one personality, but both methods and results have been stamped with individuality.

This period has had the advantage of independence and opportunity, and so it will continue to have. Until very recently no effort

has been made to unify the subject work in any way. Valuable suggestions leading to greater uniformity of treatment have been made by the committee of ten. The outlines prepared by the National Educational Association and by the college examination board have also been steps toward a certain uniformity; and in New England informal conferences, participated in by teachers of geography and geology, have looked toward the same end. This individualistic phase through which we are passing is about to give way to a period of greater unity. We have been working toward the same ends, but we have pursued diverse means. By experiment, comparison, and elimination we have established certain principles of work, even in the laboratory and field work, where the greatest divergence has existed. From our various experiences I think we may safely be said to agree on a few simple fundamental principles. Among others, that the subject should be largely a laboratory subject: that the laboratory work should consist partly of outdoor work, the character of the latter to be largely controlled by the natural features of the locality; that the time given to it should equal, if not exceed, that given to text-book work, and that it should follow the order of subjects as given in recitations and should precede the recitation if possible. Our work should proceed from the general to the specific, aiming to cultivate power of inference, independence in thought, practical observation, and the ability to visualize from type forms. It should acquaint the pupil, by means of description, map, or model, with a large number of type forms, which he will at the end be able to classify and extend to a wider application. Both text-book work and the laboratory work should be most definitely laid out in order to obtain the best results when dealing with the immature minds of our high school children.

Some believe that the text-book of physical geography is still to be written, and as this is undoubtedly true of all subjects in the school curriculum, it must needs be true in so new a field as the new geography. The great need of the immediate future is a laboratory book which shall follow quite definitely the order of work in our best text-books. Such a book would be of the greatest help in systematizing the subject, and also in giving courage to teachers who have not had special training and who dread to initiate work with which they are themselves unfamiliar. A beginning has been made, and the need will soon be met by a satisfactory book of suggestion and outline. I hope the time will never come when forty exercises in physical geography shall be laid down as a necessity for the secondary schools sending pupils to college; for, from the very nature of our laboratory work and material, no arbitrary outlines can be followed in detail. Outdoor observations on the Atlantic coastal plain must of necessity differ from corresponding work in the old land of New England or

the Delta of the Mississippi. Among our immediate needs, also, I would place additional monographs on geographical subjects and an increasing number of State and town geographies, all of them up to the standard of those at present published.

The position of physical geography in the school curriculum must be a surer one, though not necessarily an unchangeable one, that can only be dictated by the needs of the individual school. More time also is needed for its proper development. In schools which give the most attention to the subject a year is now allowed for it, and this is well; but if an opportunity could be given to large numbers of the entering class in high schools to study physical geography in an elementary way, and then this could be followed by a half year of advanced study later in the course it would be better. In the crowded condition of the high school course I doubt if this would be practicable in many schools. The value of physical geography being proved both as an informational and disciplinary subject, our experts in school administration will in the end give it a recognized place. Let the number of schools where geography is taught increase just as rapidly as it can be taught and taught well. It is already popular in large schools; it ought also to extend to country schools. It can be taught without elaborate equipment in such schools, where working material is ready at hand and where outdoor observations can be most easily made.

As the years go on and the need both of professional and technical training among teachers is made more manifest in the schools, this demand will extend with even greater force to the teaching of physical geography; and knowing something of the liberal manner in which the teaching ranks are recuperated each year we need not fear a dearth of teachers with the necessary equipment, even in this comparatively new field.

The teacher of the next few years will still have great opportunities for original work, and will at the same time have as a foundation for work the practical results of others' experience. He will find a stronger popular sentiment in favor of natural sciences and a greater willingness on the part of school authorities and among the pupils to work experimentally, both out of doors and indoors, and the subject will all the time be a progressive one. An opportunity to watch development and to see actual results is a greater opportunity than that of taking a subject at its height and with only the possibility of keeping it up to that point or struggling against its decline. Without desiring that the work in physical geography shall be one of absolute uniformity, it will yet be an improvement in the futur[illegible] maintain a greater uniformity of general principles, a more [illegible] attack and a surer touch in treatment to emphasize the pr[illegible]

growth and change, to recognize the human side more fully, and to build up a system of classification which shall enable the student to grasp the subject more comprehensively and give to him a working standard with which to measure the world wide.

We look back upon a period of disintegration and decay, when old methods proved their futility and gave way before the new. We are in the midst of a period marked by rapid-progress experiment, by rapid growth, and accomplishment. We look forward to a period of increased vitality, increased accomplishment, increased certainty.

GEOGRAPHY LABORATORY WORK

By W. H. SNYDER, Worcester, Mass.

Although the scientific method, as it is called, has for several years been used in the teaching of a variety of subjects, and the laboratory and the notebook have become factors in many lines of instruction, yet for some reason geography, one of the oldest of the sciences, has, except in a few instances, continued to be a subject of authority and memory. Statements are made and conclusions are drawn, but there is no attempt at anything more than a pictorial illustration of the statement or an unattractive and often unintelligible diagram as a proof of the conclusion. The maxim that "the way to learn is by doing" seems in some way not to have been made applicable to this subject. There is no question but that very much can be learned from good pictures and good diagrams, but there seems at present to be danger of overdoing this side and of making geographies largely picture books. Cursory looking at illustrations, even though there may be a word of reference to them in the text, especially when these illustrations are small and often poorly printed, do not bring conceptions home to the untrained mind. Ideas need to soak in. It was found long ago in physics and chemistry that illustrations in the text did not fully illustrate, but that if a real conception of the facts presented was to be obtained it was necessary for the learner to do as far as possible the processes which were discussed. The slow and self-responsible doing of something which has been described brings out the details, holds the attention to the subject under discussion, and gives time for the mind to grasp the ideas that are presented to it.

It is true that geography does not as readily yield itself to quantitative experimentation as many of the other sciences, but in the early stages of science teaching there is great danger of insisting upon too much quantitative work even in the subjects which most readily adapt themselves to this work. It is somewhat doubtful if the present tendency to make the laboratory work in elementary physics and chemistry so largely quantitative is not reducing the usefulness of these

subjects as educational factors and stupefying the scientific imagination. Probably the right order of action, both in science and in life, is to try and conceive first what might be and then measure and compute how it can be brought about. There seems, however, to be a tendency at present to measure and measure, but not to try to imagine. It may be that the difficulty of making geographical exercises largely quantitative is rather an advantage than a disadvantage. Of course reference is made here to the earlier years of the work. When a student has once attained the power to imagine and imagine why, then it is time for him to carefully verify his conceptions. When he has attained this point there will be no lack of geographical problems which will present themselves to him for his most careful and accurate consideration. He will have all the chance for quantitative investigation for which he has time and ability.

In the study of geography perhaps the first concept that must be acquired is that of space and area. Although the study of home geography is essential and necessary, yet this can never become more than a small part of the subject. Places which are far away from home and areas and elevations which are vastly greater than those that are commonly seen must be considered and a conception of their relation to each other and to the home locality obtained. The statement is usually made early in the study of geography that the earth is an oblate spheroid, with a diameter of about 8,000 miles and a circumference of about 25,000 miles. It might exactly as well be said, as far as any true concept of the size and shape of the earth as obtained by the pupil is concerned, that the earth is a parallelopipedon 100,000 miles in one direction and 1,000,000 miles in the other. Neither of these statements expresses any readily comprehensible reality to the ordinary student. Both are mere words. A little further on the areas of different countries and grand divisions are stated. Such statements must be made and appreciated if any idea is to be obtained of the conditions and resources of these countries, but yet very often there is no effort made to associate these statements with any known concept that the pupil has ever acquired. If the different maps used were all made to the same scale, then by comparing the areas upon the maps an idea of the relative sizes might be obtained, but until the recommendation of this congress, which now for the first time seems likely to be carried out, is accomplished no such uniform maps are attainable. The maps that at present must be used are of very different scales and are often so constructed that different parts of the same map are not on the same scale. Thus our best methods of geographical expression become a hindrance rather than a help in obtaining right ideas of area.

Now, it rarely happens that any pupil can be found who has not a somewhat accurate appreciation of certain distances and areas

from having traveled over them. If, then, these known distances and areas are taken as a unit of measure and from them other lengths and areas constructed to scale by the pupils, a true appreciation will be obtained of the new lengths and areas. There is no need of making a great number of these constructions, for if they are properly graded other lengths and areas can be referred to those already platted.

The shape and size of the earth can also be made conceivable by drawing a circle to scale and then shading in the flattening at the poles. It will then be found that the oblate spheroid idea has been worked to the limit. Only in this way will the pupils ever begin to appreciate the size of the earth and its almost perfect geometric shape. If the highest points of the land and the greatest depths of the sea are platted upon the circle, using the same scale, the smallness of the inequalities of the surface as compared with its extent will become apparent. It is not enough that a text-book should have areas of countries platted to scale in it, since there is no correlation with areas known to the pupil. If there is to be any reality to the platting, it must be done from the data by the pupil himself. Time is also needed for him to grasp the purpose of the platting.

It is usually believed that the historical order for the presentation of a subject is one of the best, but in geography that order seems to have been abandoned long ago. The ancients found out something about the earth's surface and then they tried to map what they had discovered. The mapping of the earth they found exceedingly difficult and several of the greatest minds of antiquity exercised all their ingenuity in developing schemes by which this could be done. At the present time, however, the boy in the high school is supposed intuitively to understand all about maps. To be sure it is sometimes a matter of a little surprise to him that on some maps Greenland and North America seem about the same size, while on others there is great difference in their sizes, but he usually considers that the man that made the maps probably saw with a magnified vision in one part of it. He may also have noted that North America is on some maps longer from northwest to southeast than it is from north to south, while on others the opposite is true, but, of course, this can be explained by considering that the continent was perhaps bloated on the day one of the maps was made. It might also possibly have been noticed that when measured on a globe the distance from New York to Liverpool was less than two and one-half times as far as to Habana, yet when measured on a Mercator map it was over three times as far. Of course this might be explained by supposing that in one case the fellow that measured the distance let his tape slip.

But really how can a science whose accredited pieces of apparatus

show such glaring discrepancies in the same determinations, unless the reasons for these discrepancies are suitably explained, expect to be considered anything more than an aggregation of approximate facts? No other science attempts to use instruments which are not understood, the construction of which can not be appreciated, and the reasons for errors in the use of which can not be readily explained. Yet, although the underlying principles upon which maps are constructed can be easily understood by the average pupil and the reasons for the faults which must necessarily occur in them readily shown, there is rarely any effort made to do this. What wonder is there, then, that geographical work is often slipshod and that elementary geography at least has ceased to be a scientific subject?

The need of laboratory work along the lines of map projection can not be overestimated. Tools must be understood before they can be properly used.

When an attempt is made to study the surface features of the earth, hachure and contour maps are used for illustration and as sources for deductions, and yet almost no attempt is made to teach the pupils the language or method of expression of either of these kinds of maps. Their plan and method of construction is unknown. In this case, although the apparatus is accurate and graphic, the pupil, as a rule, sees nothing clearly, but simply tries to persuade himself that he sees what in reality he only guesses. This error in instruction can be entirely remedied by using models as a basis for the construction of contour maps in the laboratory. In this way the pupil becomes acquainted with their detailed expression, so that when a contour map is placed before him its different features stand out almost as vividly as in a model.

In dealing with the atmosphere it is now usually considered that laboratory work is somewhat necessary, but even here many of the principles which could be easily demonstrated to the pupils are left for them to take on authority and without adequate appreciation on their part, so that the generalizations which are later attempted become simple matters of memory. Physics has usually not been studied, so that the whole matter of atmospheric circulation becomes simply a matter of authoritative statement. Here is a field where experiments and exercises can be easily provided and the foundations of the subject made clear. This has been attempted with success in that admirable book of Professor Ward's, which will probably for a long time be the basis for work in the meteorological laboratory. In this book, however, the elementary principles are not considered, as it is taken for granted that these are understood, whereas the elementary student, as a rule, does not understand them. Usually but a few of the elementary experiments in pneumatics are needed to show

the conditions under which a gas exists and the effect upon it of exterior forces. With the aid of such experiments the causes and the conditions of atmospheric circulation may, to a reasonable extent, be understood.

When we come to the action of the ocean great difficulty is found in preparing suitable experiments. There are, however, some simple exercises on wave transmission which will show the pupil how it happens that waves can move from place to place and yet not transfer the water. There are also some valuable experiments on the density, compressibility, freezing temperature, expansion when freezing, evaporation, etc., which can be easily performed and which will throw a flood of light upon the action of this most important geographical agent and clear the way for deductions which can not themselves be illustrated.

This is no time to enter into the discussion of what particular experiments and exercises are best for a course in geographical laboratory work. A number of articles have discussed this matter during the last few years. The author of this paper has stated in several articles in School Science and The Journal of Geography what exercises he considers best—those he himself uses. Several teachers in Chicago have recently united in publishing an excellent book of exercises. The material on this subject is considerable and is continually growing.

What we need to-day is an awakening to the fact that if geography is ever to take the place in the educational programme that it deserves it must be scientifically taught and that the old method of simple authority and learning by rote must be done away with. There is no educational value to learning sentences. The apparatus of geography must be understood before it can be properly used. Ideas and concepts do not readily come to a student from the simple reading of the printed page. We learn by doing. It is not possible, fortunately, to teach everything in geography by the laboratory method. If it were, we might possibly get the laboratory insanity which some of our sister sciences are just recovering from; but there are many parts of the subject which can be so taught and which ought to be so taught. The geographic laboratory is the cheapest of all laboratories to establish and is one of the most interesting and valuable to the pupils. A small expenditure of money, with a moderate amount of brain and hand work on the part of the teacher, is all that is necessary for its establishment and equipment.

One thing must be guarded against with elementary pupils and that is the excessive use of simple map exercises and cross sections. There must be variety in the exercises.

It would not be proper to close a paper on geographical laboratory work without saying something about field work. The amount and

value of the field work that can be done in any place will depend upon the local conditions. Few teachers can get sufficiently small classes and sufficiently long periods to make any considerable amount of field work profitable. Field play is demoralizing. Field work is fine, but it is often unattainable. Laboratory work is almost never unattainable. To the elementary pupil the laboratory is fully as valuable as the field. A combination of both is best, but if either must be eliminated let it not be the laboratory. The insistence can not be made too strong that it is the duty of the geography teacher to see that the pupils really know why and do not simply take all statements as authority. In the other sciences it has long been found that personal work by the pupils is the only means of impressing on their minds the realities of scientific deductions. Why should not the same truth apply to this subject, and why has its aptitude for laboratory work been so long neglected?

PRACTICAL WORK IN SCHOOL GEOGRAPHY

By R. H. WHITBECK, Trenton, N. J.

No line of development in modern education has been more remarkable than the growth of science teaching by the laboratory method. "Study things themselves; learn by first-hand experience," is a universally accepted principle. The general principle is established and the working out of the details is progressing rapidly. A decade of experimentation by practical teachers has yielded well-organized plans of work in chemistry, physics, and biology. Laboratory courses in these sciences have been outlined and are practiced with pretty general satisfaction. But what about geography? Certain it is that in this field matters are in an unsettled state, at least in America. There are people who question whether geography is really a science at all. There is lack of agreement as to what should be included under the term and what excluded. Anyone who has attempted to define the scope of geography has found how elusive and elastic are its boundaries and how numerous its ramifications into all other fields of knowledge.

Physical geography is accorded a place among the sciences, but it does not so readily lend itself to the laboratory treatment in schools as do chemistry or biology, or even physics. In the very nature of the science laboratory practice can not form so large a part in the study of physical geography as it does in the other sciences named. In the broader field of general geography this is even more largely true.

Glance down the table of contents of a school text-book. It is evident that geography treats of an almost endless lists of places, activities, phenomena, and relations scattered over the entire earth, and that most of these can not be studied at first hand unless we travel over the entire earth. Deserts, mountains, oceans, glaciers, and a thousand more of the real things with which geography deals can not be brought together for study in one place. Manifestly a very large part of a student's geographical knowledge must be gained at second hand unless he is able to travel extensively. Principles,

processes, and type forms may usually be found illustrated near home. Particularly is this true of the physical side of the study and also of the commercial. The meteorological phase of the subject is, of course, well suited to first-hand study in almost any school. Every locality furnishes opportunities for some outdoor studies, and these opportunities should be used to the utmost. Such studies are the life blood of school geography.

Regarding indoor laboratory work in physical geography one scarcely knows what to say. Very few schools indeed have achieved any notable success along this line. The laboratory manuals thus far produced are confessedly unsatisfactory, and each one differs radically from every other.

In the geography of the elementary school systematic laboratory work is as yet unknown, but observation and experience are impressing upon us that there are forms of practical work which may enrich our geography teaching and enhance its value. It is with these elementary exercises that this paper chiefly deals. For convenience we may classify the exercises as follows:

I. Manual exercises, including—
- (*a*) Modeling in sand, clay, or pulp.
- (*b*) Map making and ordinary map drawing.
- (*c*) Making of special maps, such as, for example, those showing productions, rainfall, or industries, including the filling in of prepared outline maps.
- (*d*) Graphic representation of important statistical facts, such as relative areas of countries, population of cities, exports, etc.

II. Observational exercises, including—
- (*a*) Study of pictures, the use of the stereoscope and stereopticon.
- (*b*) Study of relief models and contoured maps.
- (*c*) Study of raw materials and their finished products.
- (*d*) Indoor study of common rocks, soils, ores, etc.
- (*e*) Visits to mills, quarries, markets, etc.
- (*f*) Weather observations and records.
- (*g*) Field trips chiefly for the study of natural phenomena and forms of a geographic character.

It is not to be hoped that all of the above will be emphasized in any one school. Such a condition would probably be worse than emphasizing none of them.

Sand molding has proved its worth in primary grades. A month ago I secured an expression of opinion from forty or more teachers from some twenty different States as to the value of the sand table. There was hearty agreement that its use is essential to clear teaching in the primary grades. Only a few of the teachers cared for the sand table beyond the fifth grade. Map modeling in pulp or putty by grammar-grade pupils may be worth while as an exercise in manual training, but not as an exercise in geography.

Map drawing, which formed so large a part of the geography

work a generation ago, seems to have been crowded out of our modern "enriched" grammar school curriculum. The group of teachers referred to above were in general agreement that the expenditure of a large amount of time by the pupil on a single map, laboriously executed, is not profitable. But the rapid sketching of maps, done freehand by the pupil, was heartily indorsed by all. The outline maps, sold by various publishers, were generally approved by the teachers. These give correct outlines of States and countries in which the pupils—usually from memory—place cities, rivers, or mountains; shade areas of ample or scanty rainfall; indicate the industrial, farming, grazing, lumbering, or mining sections, the great trade routes—in short, any of the larger facts in which location is a matter of importance.

The practice of graphic representation in geography is worthy of more attention than most teachers give it. Statistics are to be avoided in geography teaching, yet to a small extent they must enter. To teach the exact population of cities or the area of States is manifestly unwise; yet to know something of the relative areas of a few of the most important States and countries and the relative population of a few important cities is useful. The graphic representation of a few selected areas of States and countries by proportional squares often opens one's eyes to long-cherished errors which he gained by studying maps constructed upon different scales. How many Rhode Island boys realize that if their own State be represented by a small square more than 200 like squares are necessary to represent the area of Texas? It may be disappointing, but it is also educative when a pupil who lives on the banks of the Hudson or Delaware draws a line of any convenient length to represent the length of his river, and then draws another in proportion to represent the Mississippi-Missouri, and finds that it takes fourteen of the former, placed end to end, to equal the latter. A graphic representation would reveal to the pupils of New Jersey that if sixteen mountains as high as the highest in their State were placed on top of one another the pile would scarcely equal Mount Everest in altitude. The value of graphic representation lies in the vividness of the impressions which are left on the mind by making these diagrams, and it should not be forgotten that the vividness of impressions diminishes as their number increases.

The second group of practical exercises may be termed observational. Most of them are studies of real things. Picture study is an imperfect substitute, but the substitution is often unavoidable. We can not see the Alps or the Alhambra in America. I judge that enough pictures are used in teaching geography—perhaps too many. If the pupil is shown a great number of pictures rapidly, no clear mental pictures are retained. My suggestion is:

First. A careful selection of a relatively small number of clear pictures which present truly typical scenes at home and abroad.

Second. That these pictures be used for actual study, each picture being accompanied by a few written questions which shall direct the pupil's attention to the salient things in the picture.

Regarding the study of relief models and contoured maps little need be said. Teachers find them so generally lacking in the human and life elements that they do not appeal to younger children. Secondary and collegiate students may use them to marked advantage.

The study of raw materials of manufacture and their products in various stages of completion, and also the study of common rocks, ores, soils, etc., may or may not be highly profitable. It is a noticeable fact that when these objects are taken from the school collection and studied, interest soon lags. On the other hand, it is equally noticeable that if the specimens were collected by these pupils themselevs, they are a genuine center of interest. They study them and talk about them eagerly. They may yawn over a lesson on specimens brought from the school museum, but be on the qui vive of interest over like specimens which they themselves have collected on a trip. In observational studies, interest is absolutely essential to good results; only the interested observer really sees what he looks at.

The last and most important phase of practical work in school geography is found in the visits to mills, quarries, markets, river banks, falls, or anywhere else where the pupils may see with their own eyes the actual things and processes about which they are studying in geography. As a trip to Europe differs from the printed description of such a trip, so, in a general way, does field geography differ from book geography. Weather observations, systematically made and recorded, form the reasonable basis for elementary meteorological studies. These studies of things just as we find them is the most valuable kind of education. In large cities, and with large classes, field trips are, of course, so difficult to provide for that most teachers do not undertake them. However, we found in the recent session of the Cornell Summer School of Geography that more than half of the teachers present make a practice of taking their classes on field trips or factory visits, and practically all of these teachers were from large cities. I asked a great many of them, "Do you really feel that these trips pay for the time and trouble involved?" and I received in all only one negative answer. But the fuller discussion of field work in geography is assigned to another and I must not encroach.

I have used and seen used in the class room every exercise recommended above. I have faith in them. They are, however, means to an end and not an end in themselves. Their value in practical use

will depend upon the clearness with which the teacher sees the end which she is really aiming at in using them, the definiteness of her purpose and plan, and her good sense in deciding what to use and what not to use.

SUMMARY

1. Scientific teaching calls for the first-hand study of things wherever possible—the laboratory method.

2. Physical geography lends itself to laboratory treatment, but not to the same extent as do some of the other sciences.

3. In general geography most of the facts must be gained by studying about things rather than by studying the things themselves; but

4. The value of geographical study is increased by the use of available field and laboratory exercises. These are both manual and observational.

5. Map sketches and outline-map exercises by pupils are a valuable means of expressing and impressing geographical ideas and a convenient means by which the teacher may test the accuracy of the pupils' knowledge.

6. Graphic representation through diagrams aids in correcting faulty notions and in getting correct ideas where statistics are involved.

7. The systematic study of pictures is a profitable form of geographical work.

8. Relief models and contoured maps are better adapted to secondary and collegiate students than to elementary students.

9. The study of specimens of any kind is most satisfactory when the pupils collect the specimens which they study.

10. Field trips, whenever possible, are the most valuable of all practical work in geography.

THE SCOPE OF GEOGRAPHY FOR ELEMENTARY SCHOOLS

By ISAAC O. WINSLOW, Principal of Thayer Street School, Providence, R. I.

The course in geography in the elementary schools is in great need of readjustment. Through the impulse of modern science the development of the field of "new geography" has rapidly enlarged the province. The constant aim of special geographers is toward an increase of knowledge, and much of the increase has found its way into text-books and courses of study. As a result of this tendency, the course has become overloaded. There is too great an amount of subject-matter and much that is out of place. We are slow to understand that the geography of advanced specialists is not suitable geography for the schools.

The situation is due to several causes.

1. *The want of proper judgment of values.*—We do not take the trouble to distinguish between that which is of comparatively small account in education and that which is really worth while.

2. *Ignorance or neglect of the capabilities and needs of children.*—The fact that pupils seem to be able to learn and recite facts and principles is not a sufficient indication that these had better be taught. The ambition to introduce difficult matters into the course as soon as possible is erroneous. We may obtain glib recitations, but after the lapse of a little time it will become evident that the subject has not so appealed to the child as to become a lasting part of his mental possession.

3. *The want of a suitable order in the development of the subject to correspond to the child's developing ability.*—We do not regard sufficiently the difference between the child of 10 years and the child of 14. The greatest hope of practical results from educational child study lies in the shaping of the curriculum more in accordance with the needs of the children than with regard to the logical arrangement of the subject-matter.

4. *The perpetuating influence of traditions.*—The force of conservatism is especially effectual in geography to prevent elimination

of the old when the new is added. Parents are pleased to have the children learn the geography of their childhood. Most teachers are inclined to present the subject as they learned it in their school days. The interests of publishers are generally opposed to reform.

The problem for educational reformers in the field of geography is to select carefully and to arrange wisely. This selection and arrangement must have regard for (1) practical utility, (2) real culture, and (3) the time to be allotted to geography in the curriculum.

The work selected in the interests of utility, or mere information for the sake of future convenience, should be thorough but comparatively brief. Definite and clear information upon a comparatively small number of points is all that the average child can retain to be called up in future years. Rather than attempt to load the mind with a multitude of minor facts, in order to be sure to have at hand the few that may at some time be needed, better leave the few to be looked up when occasion arises.

After due regard for utility and convenience, the remaining time is available for purposes of culture, and the task is both important and difficult to determine what is really conducive to that end.

The ability of children to comprehend astronomical and mathematical relations in geography is largely overestimated. The power to exercise broad mathematical imagination is rare and develops only after considerable maturity. Let anyone recall, for evidence, the struggles of his own childhood to grasp these conceptions, or examine a class of school graduates upon their ability to form them. With children we should confine our efforts to the simplest of such notions and enforce them by realistic illustrations.

It is a mistake to suppose that physical geography, when studied as a separate discipline and for its own sake, awakens much interest in children. The present spirit of dissatisfaction and reaction is partly due to the fact that the "new geography" has gone to an extreme on this phase of the subject in the school course. The recent text-books in general use start off with a load of generalized science which tends to produce weariness and is prejudicial to subsequent interest. We can not do without a certain minimum of physical treatment as a basis for causal explanation, but should restrict ourselves to such elementary principles as are surely needed, and these should be introduced not all at once, in a general and abstract way, but in close connection with concrete examples as these incidentally arise.

The sympathetic attention of children is attracted most of all by the people, and by particular people in particular regions; hence, if we are to secure interest from the beginning, we must commence as

soon as possible to introduce actual human beings residing in actual localities, leaving the scientific aspects of their environment to be worked in incidentally when favorable opportunities arise.

Acquaintance with the customs and institutions of a people is best gained through the history of their development, and school geography must include an account of such significant points in the history of each people as have contributed to their present characteristics.

A general knowledge of descriptive and political geography is essential. Children should become familiar with the numerous divisions of the land of the earth, as occupied by various peoples, and with the most prominent natural features and cities within those divisions. In the study of the home region this knowledge should be accurate and should be extended somewhat to minor details, but in connection with regions more remote such work should be carefully limited. To the average American child, for example, a knowledge of the exact form of the German Empire and of all its rivers and numerous cities has little value for either utility or culture. Its general location with reference to the countries around it, the fact that it borders upon the sea, and an account of the Rhine River and of the cities of Berlin and Hamburg will suffice for a permanent working background. It is far better to have such a simple picture clearly impressed upon the mind and to leave additional features to be filled in from time to time in after life than to produce confusion by endeavoring to include everything that one might ever have occasion to know.

A very large part of the sphere of geography should be devoted to industrial considerations. From the beginning to the end the industrial aspect, broadly interpreted, should constitute the central purpose. The deepest interests of children are centered in human beings and their customs and activities, and the more mature mind of the present generation finds chief concern in the conditions that lead to the great characteristic industries of the various regions of the world and the results that follow from them. It is on this side that geography enters most largely into the practical and the intellectual life of the world. Such knowledge as this the child of the present century needs in order to be at home in his world. The limitations of time in the school course render it impossible to enter minutely into the particular methods of industrial processes and the strict limitations of the work of geography exclude activities or processes which are not determined by geographic considerations, but the customs of life in each country and the prevailing industries to which the country is especially adapted should receive strong emphasis.

As the culmination of such industrial treatment, a knowledge of

exchanges of the leading products among the various regions and of the principal routes and methods of transportation should by all means be included. The leading facts of commercial geography belong in the elementary course. If this withdraws too much from the work that has been reserved for the high school, let the place be filled by postponing a portion of the treatment of physical geography with which the elementary schools are unprofitably burdened.

The sum of the several divisions of geographic knowledge herein outlined, if carefully selected and presented, will not exceed the proper limitations of the subject, will render it the most interesting and popular of all the branches of study, and will furnish an adequate equipment for average citizenship.

FIELD WORK IN THE ELEMENTARY SCHOOLS

By ZONIA BABER, University of Chicago

It is a recognized law that an organism develops through satisfying its needs, and that it assimilates only that which it requires for its growth. If, however, the proper stimulus is lacking, or reaction to the stimulus is inhibited, growth ceases and the organism becomes atrophied.

Since this law holds good in the realm of intellect as well as in that of the phsyical being, the knowledge of the reaction of the child's activities to natural and social stimuli would form the most valuable contribution to human acquirement, since it would enable education to take its place in the parliament with physics, chemistry, and the other natural sciences.

However humiliating to the teaching force the fact may be, the statement remains undisputed that the science of education, which is the greatest of all sciences since it deals with the human soul, has lagged far behind the other sciences in its development.

A few principles relating to the scientific process in education have been discovered and formulated, but they have not been the controlling factors in the warp and woof of the educational fabric. With the principle ringing in our ears—mental activity is dependent upon self-experience—we proceed to make schools which successfully inhibit the child's gaining new experiences, confining him to the experiences of others, and after years of study of texts his enthusiasm for learning may frequently be represented by an inverse ratio to his scholastic experience.

When we contemplate the task the school formerly set itself, that of perpetuating book lore, we are not surprised when we read the sign written in invisible letters on the façade of almost every schoolhouse, "A Refined Cramming Industry, Limited."

Knowledge has accumulated with such prodigious rapidity that the school now cries out in despair, "The task is Herculean; it is impossible!" Even if it were possible to stretch the elastic memory until it could retain all known facts the result would be deplorable. Al-

though one may be able to repeat volumes of the world's richest knowledge, it has no meaning to the individual unless assimilated by self-experience. Character is not made by repeating what the wise and good have said, but in saying and doing something wise and good on one's own account. After a few years of the cramming process the student becomes a slave to second-hand experiences. He is helpless when confronted by a new situation without the sustaining crutch of the text-book. The individual loses the power of initiative, independence, vigor, and integrity of mental action.

We are beginning to discover that we have made knowledge the end instead of the means of reaching our goal. To give the individual control of all his powers, to bring him to a realization of his highest possibilities, should be the aim of the school, not the acquisition of facts. This can not be accomplished by the use of text-books alone.

Before our population was urbanized the child gained possession of his powers by first-hand contact with nature and by participation in the industrial activities of the home. Now the school must assume the responsibility of the industrial training once given in the home and the nature study furnished by the farm. To this end our schools are slowly introducing cooking, sewing, weaving, work in wood, clay, metal, gardening, and field work.

Contact with material furnished by nature engenders a certain mental activity which the mere observation of conditions fails to satisfy. This need we term a problem, and it is to the mind what appetite is to the body; it determines the food necessary for growth; it focuses the energy toward a definite end; it directs attention and observation for the collection of data from nature, books, people, and cultural products; it calls the imagination into play in forming hypotheses, and, if properly utilized, tests the hypotheses by experiment, selecting relevant material, discarding the irrelevant, until a conclusion is reached which bears the test of reason.

In organized mental action the individual finds the highest pleasure. The student who is given opportunity for the exercise of all his powers from his entrance into school needs no prize, per cent, nor degree to stimulate him to industry. The reward is in the joy of the doing.

It is only through the solution of the student's own problem that he gains true intellectual development. The power of imagination, reason, observation, memory, can not be developed except by the presentation of conditions which stimulate mental activity in connection with the mind's own normal movement. It is true that the mind may be trained to tricks of memory or observation, but it has been shown that this acrobatic mental skill does not go over into the intellectual power of the individual.

Field work offers an opportunity for such individual development.

Every region is rich in problems for the student from the kindergarten age to the adult. Even the 6-year-old has a problem when he makes an excursion to the farm to see how the farmer overcomes difficulties in tilling his crops and tending his stock. In his own little garden the seeds may be planted by hand, tilled with a hoe, but the farmer must devise other methods for his larger work.

Excursions to the seashore or lake shore, to a river, to sand dunes, to a mountain, volcano, swamp, to regions where glacial phenomena are illustrated, to quarries or mines, will furnish physiographic problems for pupils above the fifth grade and bring the younger children into first-hand contact with natural objects in their normal setting.

Few localities can boast of all these geographic examples, but many may be found within a radius of from 15 to 30 miles from any school.

Many of the world's important industrial activities, such as farming, lumbering, grazing, fishing, mining, manufacturing, quarrying, building, trading, and others may be seen within the same radius.

Through visits to the accessible industries the student gains an appreciation of the cultural products of the earth. Greater returns may be expected from a single visit to a certain industry if the students are engaged in the same activity at school or at home.

It is rare that a physiographic area is so simple that one visit may exhaust its possibilities. When changes are taking place with noticeable rapidity, as at the seashore, in the river valley, or at the sand dunes, visits from year to year give the dynamic conception of the mobile crust of the earth.

Young children form definite images only through many contacts with the same material, and they retain definite images but a comparatively short time. Hence they require many and frequent excursions.

From the kindergarten age to the age of 10 or 11 years the excursions furnish an opportunity to bring the children into contact with animate and inanimate things in their natural environment. Children of this age are interested principally in collecting material in the activity itself rather than in causal relations, although the important aspect of cause is not excluded from their wide range of investigation of the wonders with which they find themselves surrounded. Interest in the relations of things can rarely be sustained, however, for sufficient time to test an hypothesis. But about the eleventh year the causal relation makes a stronger appeal to them, and about the age of 13 or 14 the student shows much interest in pure abstract thinking.

Although interest in physiograhpic processes may be manifest in a certain degree as a result of field work in any of the grades of the ele-

mentary school, yet it is in no sense a dominant factor until the upper grades are reached. Here interest in the problem will carry the student through a series of experiments with running water, waves, air currents, and other forces, testing his hypothesis to ascertain the cause of observed phenomena, and will also lead him to search books for further data which may contribute to its solution.

The benefit of the excursion is not exclusively intellectual. It is useless perhaps to mention the physical advantage of exercise in open air, since this is self-evident. But the social relation of teacher and pupil and of the pupils with each other is so normal and natural, free from the artificial conditions which perforce of circumstances must obtain in even the most natural school, that the teacher has an opportunity to reach the real child too often screened in the schoolroom.

Admitting the desirability and necessity of changing the center of gravity of our school system from the slavish study of the text-book to a study of the environment, with all its activities, which requires for its understanding knowledge of other times and distant climes, the task at present is a difficult one. In the first place the change of standpoint is so recent that teachers themselves reared for the most part on the text-book plan, are illy prepared for any other work. Where there is an attempt to carry out a new ideal, the community, always conservative, wishing to cling to traditions, frequently puts obstruction in the path of the aspiring teacher. This difficulty may be removed by educating the community through the children and through parents' meetings. The expense which is necessarily attendant upon field work is also a matter of grave consideration in most regions. We spend money readily upon the things for which we have a habit of spending, but hesitate when a new expense is incurred. When field work becomes customary either the parents or the school trustees will defray the expense, just as they do for every other feature of our school system which is considered essential.

Another difficulty results from the large numbers of children for which each teacher must, under present conditions, be responsible. The physical care of 50 children on an excursion is no small responsibility. An extra teacher is a necessity in each school building to aid the regular teacher on her excursions or to attend to half the students during her absence. With care, accidents are rare. In sixteen years' experience in the field, with many hundreds of children, I have never known of a single accident during an excursion. Large classes are not desirable in field work or in the class room, yet they are not prohibitive. The individual must suffer in collective treatment in the field as well as in the schoolroom. But the field, with its numerous aspects, gives opportunity for satisfying interests of each individual which the schoolroom frequently denies. The interest manifested by a class in the discussion of a field trip leaves little

doubt of the superior vitality of knowledge gained from self-experience compared with second-hand information.

The organization of the elementary school is far more favorable to making field excursions an integral part of its work than is the high school. The departmental teaching in the secondary school makes it next to impossible, with the attitude of the teachers of the special subjects, to have excursions except after school hours or on Saturdays. This puts the field work at a disadvantage; but in the elementary school the teacher is mistress of the situation. Although Pestalozzi introduced field work into his geography teaching at Yverdon, Switzerland, a hundred years ago, the schools of this country have been slow in realizing its value—in recognizing that it is fundamental to all true geography teaching.

DISCUSSION

Miss ARNETT: In answer to the objection that large classes are prohibitive, I desire to say that I have seen Doctor Cowles, of the University of Chicago, conduct parties of 50 or more in botanical field work with great success. His plan was to have maps and itineraries prepared beforehand, and a copy furnished each student, the itinerary suggesting the problems to be seen in their proper places. Often these suggestions were in the form of questions. These problems were then discussed in the lecture room upon the return of the party. I have tried the same plan successfully with high school and normal school students, and a modification of it with elementary school children. Small classes are better, but the work with even large ones is profitable.

Professor GULLIVER: A large number of students makes field work difficult if not impossible. The number of students should not exceed 15; otherwise field work will have the defects of schoolroom work.

Professor DRYER: I have conducted field classes of 300 or 400 persons, with the assistance of three or four subordinates, and have found them sufficiently fruitful to be continued every fall and spring. With proper prearrangement and proper instruction to the students as to what they are expected to observe, and with extended quizzing upon what they have seen, such excursions, I am convinced, are well worth undertaking.

GEOGRAPHICAL SCIENCE IN HUNGARY

By BÉLA ERÖDI, Budapest, Hungary

It is only quite recently that Hungary has displayed any considerable activity in the field of geographical science. The work began with the foundation of the Hungarian Geographical Society, a step due in the first place to the First International Geographical Congress, held at Antwerp in 1871. Before that date, indeed, we had distinguished writers on geographical subjects, who compiled works of lasting value; but they are few and far between. Geographical science, indeed, before the appearance of the great Humboldt was everywhere in its infancy. The "Bibliotheca Geographica Hungarica" of my fellow-president, Dr. Rudolph Havass, proves that our geographical literature has a distinguished past, for up to the middle of last century it could call about 5,000 works its own. "This rich library," says the author, "bears testimony to the fact that despite all the oppression and suffering our nation experienced in the past the genius of Hungary never allowed the enlivening and enlightening fire of intellect to go out, even in the field of geographical science."

In the forties of the last century at the meetings of Hungarian Physicians and Natural Historians a modest place was given to the geographical science among encyclopedic sciences, and a few valuable monographs were published.

One department of the Hungarian Academy of Sciences, founded by the "great Magyar," Count Stephen Széchényi, in 1825, includes geographical science, too; its publications include some works on geography; but since the foundation of the Hungarian Geographical Society it has transferred most of its work in this branch to the latter. The Natural Sciences Society, which was founded in 1841 and has to-day a membership of 8,500, having acquired for itself a leading position among scientific societies and possessed of great wealth and a library of some 20,000 volumes, from time to time publishes geographical works. Among its publications are to be found

Louis Lóczy's work on China, Otto Hermann's book on the Bird-mounts of Norway, and, quite recently published, George Almássy's work concerning the journey he made into the heart of Asia. After the restoration of a constitutional state of affairs in Hungary, in 1867, the nation roused itself to new life, displaying feverish activity in politics, social life, science, and art. The nation became aware that it must make up for a century of inactivity. Scientific and intellectual societies were founded in rapid succession, and, hand in hand with the State, made great efforts to advance the progress of the nation and to compete with other states, which, by their more favorable position, had been able to do more for science. The late Crown Prince Rudolph set a good example by placing himself at the head of the movement, and, supported by a staff consisting of the most distinguished scholars, set to work to compile and publish the important book he had planned, treating of the soil and peoples of our country and of the other State in the monarchy. This was the origin of the great work entitled "The Austro-Hungarian Monarchy described by Word and Picture," which up till now has appeared in 21 volumes, in Hungarian and German. The chief of the staff editing the part dealing with Hungary was Maurus Jókai, who died not long ago, and is mourned by the whole country. The great work was in preparation twenty years and its last volume left the press only last year.

There are so many various branches of geographical sciences, so many spheres of action, that every department of government has some work to do for it.

The Hungarian Government has spared no pains or expense in founding various institutions, all of which are to further the progress and development of our science.

In 1869 the royal Hungarian minister for agriculture established the Geological Institute, which first of all worked for two years as a geological department. The task of the institute is to make a detailed geological survey of the lands of the Hungarian Crown, to prepare maps and descriptions, to establish lithological and paleontological collections, and to supply characterizations for agricultural, mining, and industrial purposes. The staff, which at first had to fulfill all these duties, consisted of a manager (director), 4 geologists, and 2 clerks. To-day the staff comprises a manager, 15 geologists, and 2 chemists. Of these 6 geologists and 1 chemist are engaged exclusively in work of an agro-geological character. The Geological Institute, which at first was in a hired house, then in the building of the ministry of agriculture, in 1900 received a beautiful palace on the Stefánia út (street). For the purpose Andrew Semsey gave 100,000 crowns ($20,000), the corporation gave a site, and the building erected forms a worthy home for the rich geological collection recently formed.

The institute displays its activity, in the first place, in the publication from time to time of geological maps, which were formerly printed on a scale of 1 : 144,000, but are now published on special sheets on a scale of 1 : 75,000. The maps now appear in colored lithography. Up till now about one-half of the country has been surveyed in detail. The literary work of the institute is comprised chiefly in the annuals, of which about 14 volumes have already appeared, and in the yearly reports, of which 22 have till now been published; besides, there are occasional special publications. It is especially worthy of notice that this national institute, in addition to its strictly scientific work, has, as far as possible, endeavored to support the interests of education, industry, and agriculture.

The hydrographical section of the ministry and the national hydrotechnical department have undertaken an enormous task, covering the whole country, in the surveying of the waterways of Hungary and the building of dams, etc. The hydrographical section was established in 1886, with the object of collecting and publishing all technical data necessary for the regulation of the rivers, protection against floods, for regulation of shipping, and of making a scientific study of the formation of the beds of our rivers, their nature and laws. The national hydrotechnical department is the adviser of the minister for agriculture in technical matters, and acts independently in its own sphere.

The Meteorological and Earthmagnetic Institute was founded in 1870, when Baron Joseph Eötvös was minister of public education. Its original, purely scientific sphere of activity was widened, duties of a practical nature being imposed upon it, so in 1893 it was transferred from the education department to the ministry of agriculture. It consists of five sections, one of which supplies the hydrographical department of the ministry with dates re rainfall and temperature; the observatory at Ó-Gyula takes special observations concerning the atmospherical electricity, temperature, rainfall, evaporation of the soil, etc.

The royal Hungarian ministry of commerce completed a work of great importance for traffic and commerce in regulating the Iron Gate, the first steps toward which were taken by Count Stephen Széchényi as early as the beginning of last century.

In 1871 the same ministry established the national statistical office and in 1874 reorganized the same. This great institution, with an enormous machinery and organization at its command, has already completed four important systematic censuses.

Quite apart from the national stands the Budapest Corporation Statistical Office, established in 1869, by the town corporation; its

object is to collect all dates required by the municipal authorities to execute a proper administration, and to display the development of the capital in every direction. The sphere of action of this office has recently been considerably extended, and its publications have in every respect been enlarged and perfected. The office has taken an active part in the development of international statistics (30 volumes).

Its library contains 32,000 volumes. By means of its publications it is in touch with all statistical offices and authorities, with all large towns abroad, and with all institutes, and has largely contributed to the unparalleled development of our capital, becoming known everywhere. The history of its twenty-five years' existence was written by Dr. G. Thirring, the vice director of the office, on the occasion of the Eighth International Hygienic and Demographic Congress held at Budapest.

The post-office, which is under the control of the ministry of commerce, published its first map (on a scale of 1:1,080,000) in 1874; this map, of which two further editions have been issued, contains all dates referring to the Hungarian posts and fulfills all requirements of cartography. In consequence of the increase in the network of railways and the number of post-offices which had in the meantime taken place, the map was republished in 1880 on a scale of 1:1,000,000, in 1883 on a scale of 1:800,000; the second edition of the latter was issued in 1885. In consequence of the union of the telegraphs with the post, all dates referring to these two branches were published together in a map issued in 1894 with the following title: The Post and Telegraph Map of the Lands of the Hungarian Crown. The map was on a scale of 1:576,000, printed in four colors on four sheets. In 1902 was published the present map, on a scale of 1:400,000, in four colors on eight sheets. Separate maps concerned with the telegraphs and telephones have been issued, the former in 1885, the latter in 1901.

The Royal Hungarian State press, which is under the authority of the Royal Hungarian ministry of finance, was established in 1869 as an independent Hungarian institution. Its task is to print (among other things) the results of measuring surveys for the State and private persons and to prepare maps concerning public interests. For this purpose the State press has been furnished with all implements for reproduction. In its library there are 11,139 technical works, model sheets, and maps. The institute itself prepares its original plans, sketches and engraves its maps and all works of reproduction. Its budget is fixed by the legislature. Since 1873 it has not only covered its own expenses, but has actually added to the revenue of the treasury. Last year, with an income of 2,101,673 crowns it was able to show a surplus of 496,671 crowns. For wages it paid 432,789 crowns. In the field of cartography the State press has pub-

lished some excellent productions. That the Royal Hungarian ministry of public education bears the lion's share in the work of fostering geographical science is quite natural, if we consider the nature of the subject. In every State it is an object of general complaint that the schemes of education do not grant sufficient time to the teaching of geography. This complaint may be heard in Hungary too. Experts find the time employed for instruction in geography, a subject so important from the point of view of general knowledge, too little.

We must acknowledge that a few more hours divided equally among the various grades and classes of our schools would be only an advantage for the subject, but on the other hand we must recognize that if we will do justice to the manifold requirements we can not very well devote more time to this subject. Again, geographical knowledge is such that almost every professor (master), if he takes his task seriously, has an opportunity to increase the geographical knowledge of his pupils. In Hungary the fundamental knowledge of geography can be acquired in the third class of the elementary schools. Beginning from the school building itself and its surroundings, the instruction is extended to an ever-widening sphere, till at last it comprises the whole country. In the eight class middle schools (classical and modern) geography is taught only in the three lowest classes (eight hours a week altogether). In the first class after three hours' instruction a week in general geographical knowledge follows the oro-hydrographical, ethnological, and political geography of Hungary. In the second class (also three hours a week), Europe, Asia, and Africa; in the third class (two hours a week) mathematical and physical geography, as well as America and Australia, is taught. In higher classes geography is not taught independently, but in connection with history. The master should always endeavor to keep a strict watch over and to give an account of all geographical details that crop up in the course of study. The same course is pursued in regard to geography in the city schools (Bürgerschule), the higher grade ladies' schools, pupil teachers' training institutes, and commercial schools. The former scheme of education for middle schools, with instruction for the same, arranged the teaching of geography in combination with natural history, while the new reformed scheme issued last year has separated the two subjects, and now each of them is taught in separate lessons by special masters.

When the educational department regulated every phase of school life, it took account of the proper equipment of schools with means of instruction. It stipulated the minimum equipment of the museums. Our schools have a cabinet of means of instruction in geography, just as in other branches of science, that generally answers to the purpose, and is in some cases actually wealthy and exemplary. Besides

maps, atlases, and globes, they have pictorial guides, photographs, and products. They are provided with sciopticons, which render the instruction more realistic and successful.

The Hungarian Government considers the publication of school books as a free industry, only reserving to itself the right of deciding whether they answer to the prescribed requirements or not, and on the ground of this investigation either recommends them for use or not. In the case of geographical school books we find a very fertile production. The publishers (the Franklin Society, Athenæum Company, the firms of Wodimer and Singer Wolfner) vie with each other in publishing them, and in consequence of the competition we are put in possession of some very valuable school books. The geographical books are furnished not only with illustrations, but also with outline maps and supplementary maps. The maps of some books are really valuable products of cartography.

At the ministry the teaching of geography has recently received a great impulse through the establishment by Government in 1890 of the Budapest Royal Hungarian University Geographical Institute and Seminary, the management of which was intrusted to Dr. Louis Lóczy, professor of geography at the university. The institute has at its disposal all instruments necessary to a thorough practice of geographical science. Its library comprises some 12,000 volumes, chiefly the gift of Dr. Andrew Semsey. Besides it is furnished with all implements and instruments necessary to the exercise of the practical experiments of geography and with a collection of nearly 6,000 photographs. In the year 1903–4 the lectures in geography were attended by almost 300 students. Besides theoretical and practical instructions the students take part in long excursions yearly.

Till now, led by the manager of the institute, they have traveled through Russia, Finland, the Caucasus, Germany, Italy, and Turkey. In every case the fact that during the last ten years geographical science has made such rapid strides and that there have been geographists here who by their work have won recognition abroad is in no small measure due to the University Geographical Institute.

The Hungarian Government has, on more than one occasion, at no small expense, arranged excursions for masters, who, in groups of 30 to 40, under careful guidance, have traveled through and made a study of Italy, Greece, and Egypt. During the Easter vacation and in the first week of the school year we often meet enthusiastic tourists, who are urged by their thirst for knowledge to explore districts lying beyond the frontier of their own country. That the excursions are mostly made to Italy to examine its classic soil and rich art treasures we must consider only natural; but there have been parties that have visited Germany, Belgium, and France too. The students of the Oriental Commercial Academy make frequent excur-

sions to the neighboring eastern States, to Servia, Roumania, Bulgaria, Bosnia, and Constantinople. Even the pupils of girls' schools (higher grade) make excursions from time to time with their masters. The education department has issued an order for regulating the details of such excursions.

The Hungarian Geographical Institute was established in 1890, thanks to the moral and material support of the ministry of public education. Its object is to have wall maps, atlases, globes, and pictures for survey, hitherto supplied from abroad, made in the country. The scientific and technical management of the institute is in the hands of Em. Kogutowitz, who in the course of time has educated a fine expert staff and has at his disposal the latest triumphs of cartography, so that the productions of the institute can compete with the finest school maps of foreign countries. Till now the institute has published 25 large geographical wall maps, 7 maps illustrating the history of Hungary, and 12 illustrating the history of the world; besides it has issued atlases for every grade of school, altogether 165 maps, 1 historical school atlas (24 maps), 10 bird's-eye views, and globes of all sizes and of all descriptions. Its detailed wall map of the Balkan peninsula (1:800,000) was noticed and praised by the Bulletin of the American Geographical Society (Vol. XXXVI, No. 4). At every technical exposition the institute has always gained the highest distinction, e. g., at the World's Exposition at Paris in 1900 it was awarded the "medaille d'or" (gold medal).

The education department supports the manufacture of the means of geographical instruction in another way, too. That Hungarian geography and history may be taught in our schools only by means of pictures (bird's-eye views) that answer thoroughly to the purpose, the preparation of pictures of artistic value has recently been proposed, and for this purpose a competition has been announced for the preparation of wall pictures with fixed subjects. In doing so the department had a double purpose: To give work to our artists, and to work upon the artistic feelings of the students by giving them pictures artistically produced.

The Government has also taken care to provide books for the university students. University professors have been called upon to write primers, which treat of the subject-matter in direct connection with the lectures delivered thereon.

The education department has always evinced a great liking for geographical science, and has readily indulged in any expense to support the Hungarian Geographical Society in its efforts. To it is due the fact that the Hungarian Government has on every occasion sent delegates to the International Geographical Congress, as well as to the Vasco da Gama fête at Lisbon. The Government has also, without fail, been represented at all international geographical meet-

ings. In a word, we have been present always and everywhere at international meetings where we could render service to geographical science. The late minister of public education, Dr. Jules Wlassics, favored our society to such an extent that he gave us a permanent home within the walls of a state school. The present minister, Dr. Albert Berzeviczy, is bound to our society and geographical science by a double tie. As a member of council and honorary member of our society he is an active member of the same, having himself appeared as a lecturer and delivered valuable lectures. But he is bound to geographical science in addition by his activity of wider dimensions, one classic product of which is the valuable work entitled "Italia," treating of that classical country, the history of which so many distinguished workers in the world of literature have made one of the darling objects of their life. Berzeviczy's Italia occupies a distinguished place in the list of great and valuable works.

Ethnography, the sister science of geography, has quite recently found some one in Hungary to practice it and make the necessary collections.

The Ethnographical Society, which in 1889 left the Geographical Society, is already flourishing, and the two sister societies, among the members of which we see many cultivators of both branches of science, display the greatest harmony in supporting each other. The Etnographia has, since 1894, been the bulletin of the National Museum, too.

The Ethnographical Museum, which is not yet an independent institution, forms one department of the National Museum, founded by Count Francis Széchényi in the early years of last century. It is connected with the Ethnographical Society. This museum was created in 1871. The first acquisition consisted of the collection of some 5,000 eastern Asiatic ethnographica, personally collected by our countryman, John Xantus, who, at the instigation of the minister of public education, Baron Joseph Eötvös, joined the first Austro-Hungarian commercial expedition to eastern Asia.

From that date a stagnation lasting some twenty-five years set in in the life of this department, which did not even receive a bounty. It was only in 1894 that it took new life, when it was transferred to separate premises and received at first a bounty of 1,000 to 1,600 crowns, which has now been increased to 6,000 crowns, for purchases. But the sum of this regular annual donation is far exceeded by the separate bounties granted by Government in each special case. Its task is (1) to procure a small but systematic international collection, extending, as far as possible, in an equal degree to all parts of the globe, for purposes of instruction; (2) to procure a complete collection referring to every parish of Hungary (ethnographical and physiological survey), extending to the environs as well; (3) to procure a systematic and scientific collection referring to races related to the

Hungarian—Finnish, Ugrian, Turkish, Tartar. To fulfill this task hitherto about 80,000 subjects, 7,000 photographs, and 800 phonograms have been collected. The most celebrated collectors have been John Xantus (Indonesia), Samuel Fenichel and Louis Biró (New Guinea), Count Rudolph Festetich (Melanesia), Count Eugen Zichy (Caucasus and central Asia), Dr. Charles Pápai and Dr. John Jankó (ostjáks), Alexander Farkas, Otto Hermann (Hungarian subjects). The institute (museum) has in 76 rooms collections exhibited for survey, a photographic laboratory, and two publications. Its bulletin in the future is to have an illustrated abridgment in German.

Hand in hand with the Government, and in competition therewith, the society has been doing its duty in the interests of Hungarian science. There are hundreds of societies, intellectual clubs, etc., which are displaying enthusiastic activity in furthering the cultivation of geography and the sciences relating thereto (history, archeology, and natural sciences).

The Hungarian Carpathian Club is strictly concerned with the cultivation of geography. It was founded in 1873, its center is in the town of Iglo, and its special task is the exploration, studying, and familiarizing of the Carpathians. It has deserved special praise for its efforts to increase the knowledge of the culture of the north of Hungary. It is a combination of nine expert sections for common work. Till now 25 yearly reports have appeared in Hungarian and German. The club has established a fine museum at Poprad. Similar activity is displayed by the Transylvanian Carpathian Club, founded in 1891, whose center is at Kolozsvar. It has 24 branches in parts of Transylvania. Its president is Count Bálint Bethlen. There is also a German Transylvanian Carpathian club, the name of which is "Siebenbürgischer Carpathenverein." This was founded in 1880; its seat is at Nagy-Szeben; it has seven sections and an annual published in German. The center of the South Hungarian Carpathian Club is Temesvar. The cultural societies at work in various parts of the country also comprise geographical science—e. g., the Transylvanian Museum Society. In the Hungarian Geological Society there is a special committee, under the presidency of Dr. Francis Schafarzik, for the observation of earthquakes and the publication of remarks thereon. The Hungarian Tourist Club, which has nine branches in the provinces, is concerned with touring.

Hungarian geographical science is specially cultivated by the Hungarian Geographical Society, founded by John Hunfalvy, its first president, and Arminius Vámbéry, vice-president. It can look back upon a past extending over thirty-two years. During this time it had at first to struggle with many difficulties, but reenforced by the material support of the Government, it has been enabled to engage in work which it may contemplate with pride. Its chief aim is

to study and make known its own country; but at the same time it keeps a watchful eye on all geographical movements abroad. It has taken part, by means of delegates, in every international geographican congress, and at its meetings lectures have been given by well-known foreign geographical notabilities. The society's bulletin, of which 32 volumes have already appeared, bears lively testimony to its activity. Since 1882 our bulletin has contained a supplement entitled "Abrégé," in foreign tongues, to enable people who do not understand Hungarian to become aware of the efforts we are making. Further testimony to our activity is borne by the Hungarian Geographical Society's library, a literary undertaking which supplies our readers with works of great value, principally concerned with scientific expeditions. In this series appeared, among others, classical works treating of the expeditions of Sven Hedin, Valdina, and Louis, Duke of Abruzzi. The society has also undertaken to edit a large geographical atlas; it wishes to supply the Hungarian public with a work of such dimensions as will be on a level with similar publications produced in foreign countries and will answer every requirement. The editorship in both cases has been undertaken by Arthur Wodianer, K. C., a member of the committee of our society, who is thereby rendering a great service to our science.

The Balaton committee, which forms part of the society, has done a work of great importance and wide dimensions. In 1891 the committee of the society decided to make the various parts of the Hungarian Kingdom an object of scientific study and to commence this undertaking by a study of Lake Balaton. Aided by a considerable material support given by the Hungarian Academy of Sciences, the Royal Hungarian ministers of public education and agriculture and Dr. Andrew Semsey, the committee made a thorough study of Lake Balaton and its surroundings. The lake and its hilly surroundings, with the forest of Bakony, must be considered as a geographical unit, which fills the center of a large basin of the third age (Miocene), surrounded by the Carpathians, the Alps, and the Balkan Mountains. The Miocene ocean again covered the district around the lake, which is now occupied by hills. The Balaton itself is a depression of the post-Pleistocene age, which is on a level with the central weight of the Hungarian lowlands. Its erstwhile bed is on a level with the lowest points of the lowlands. The topographical, geological and paleontological, physical, geographical, biological, and sociological movements of this interesting district have all been taken into consideration. The committee can count among its collaborators the most distinguished expert scholars of Hungary and foreign countries. The results (of the researches) are being published in three volumes and an atlas, in Hungarian and German. Volume I gives the physical geography of the Balaton and district;

Volume II contains the biology of the Balaton; Volume III the social and physiological geography of the Balaton district. As Part IV is added the topographical and geological atlas. The greater part of the work is ready, and the great undertaking, which has occupied the committee thirteen years, is approaching its completion. The president of the Balaton committee, Dr. Louis Lóczy, professor of the university, by successfully completing this work of large conception, which is almost unparalleled, has won for himself the gratitude of the world of geographical science.

The popularization of geographical science is in no small measure due to the institution called " free lyceum," which arranges separate lectures and series of lectures for adults; among these lectures a distinguished place is taken by geography. The lecturers visit the factories too, when, after work is over, workmen who desire to improve themselves fill the lecture rooms to overflowing.

The " Elizabeth People's Academy," which was founded last year, exclusively for the purpose of intellectually educating the working classes, included many geographical lectures in its programme. These lectures are made more interesting and instructive by magic-lantern slides and specimens. The same work is done by the university extension movement, which, by arranging a series of geographical lectures for the educated public, has rendered great service to our science.

The most far-reaching results in the popularization of geographical science have been attained by the Urania Society and the Urania Theater of Sciences connected therewith. This society, which has made it its aim to popularize and spread the knowledge of geography, ethnography, and natural sciences, though it has only been in existence a few years, has made such rapid strides that, in respect of membership and wealth, it has already surpassed other societies of older standing. The Urania Theater has become the indispensable temple of popular culture. It has only been in existence five years, and yet it has already produced more than 100 pieces, mostly geographical, with a view to familiarizing our public with the outside world. Some of these pieces are of more than passing value and have actually gone abroad to make conquests. By arranging special lectures for schools, the Urania Theater is helping schools to do justice to their educational task.

I must also make mention of the undertaking which has made its aim to write and publish monographs on the counties of Hungary. Sixty-three volumes are to be issued, one for each county of Hungary. Up to the present 10 volumes have been published. The monographs include treatment of every phase of county life, but are chiefly concerned with geography, ethnography, natural science, and history.

In the history of geographical explorations and discoveries no mean place is that occupied by Hungary. I have the honor to present to you a map, on which the routes of Hungarian discoverers and explorers and the territory explored are worked in colored lines. You will see the names of 31 Hungarians on this map. We could display the names of others, too, but we will mention only the best known and most distinguished—those whose names will surely not be quite unknown to you. Many of these explorers took up the wanderer's staff with the intention of visiting the old home of their ancestors or peoples related to the Hungarians, and of studying all that could throw any light on the subject. The number of those who started with this intention is large indeed; but in serving a national cause, they served international interests, too. It was with such an intention that Julian, a Dominican monk, who, from 1235 to 1237, at great risk and at the cost of many trials, traveled in Asia and actually did discover Hungarian tribes in the old home, started on his way. He was the first Hungarian who gave a detailed description of his expedition to Asia.

On June 3, 1769, Helle and Sajnovics, Hungarian Jesuits, observed at Wardoehuus the transit of Venus, and were the first to call the attention of the Hungarians to the Laplanders, whose tongue they declared to be related to that of the Hungarians. Alexander Kōrōsi Csoma, who in 1822 traveled through Tibet and in Buddhist monasteries studied the Tibetan language, which he considered related to the Hungarian, made it his task to render service to this national cause. He thought to find the relatives of the Hungarians in the Gungar tribe, which live on the frontier of China, northeast from Lassa. The London and Anglo-Indian papers speak of him with reverence, calling him a first-class scientific explorer and linguist. Our learned countryman is sleeping his last sleep at Darjeeling, at the foot of the Himalaya Mountains. Almost at the same time as Körösi Csoma was working in south Asia A. Reguly was looking for kinsmen of the Magyars in the north among the Finn-Ugrian tribes of Siberia. He, too, suffered many trials and endured many hardships while traveling among the Votjak bashkir—Vogul and ostjak—people and completing his ethnographical and linguistic reseaches. In his steps followed later on John Jankó, who studied these kindred peoples from an ethnographical point of view. Pápai and Munkácsy studied the question of kinship with the Magyars among the peoples of Siberia.

A similar journey was made by J. Bessze, who, in 1829, in the company of Humboldt, traveled through the Caucasus and was the first to attempt to climb the Elbours Mountains. Later he traveled in East India and Madagascar. In the latter place he ended his earthly pilgrimage. His work on his travels was written in French, as he

himself says, "Pour servir l'histoire de Hongrie." Magyar traces in Asia were looked for by Berzenczy in 1873, and chiefly for the purpose of economical studies by Ónody in 1873 and 1876. In 1873 and later in Mongolia, Gábor Bálint, living in the country of the Khalka Mongols, learned the Mongol and Manchurian languages. Long before, Arminius Vámbéry, who in 1863–64 traveled, disguised as a dervish, through China and Bokhara and became a high authority for all matters relating to the Turco-Tartar peoples, was traveling in Central Asia for the purpose of making a study of Hungarian linguistics. Ch. Ujfalvy, with his French wife (Mme. Bourdan) was also in central Asia in 1877. By his travels in the regions of the Caucasus and the Himalaya M. Déchy also won for himself a name. Count Eugen Zichy also sought Magyar connections in the Caucasus. Later he traveled to China by way of Mongolia. Before Eugen Zichy, two brothers, Counts Augustus and Joseph Zichy, traveled over the same country (1875–1878). Very successful was the Chinese expedition of Count Béla Széchényi (1878), the members of which were G. Bálint, Louis Lóczy, and Lieutenant Kreitner. The expedition explored parts of China hitherto unknown to Europeans, but could not reach Tibet, whither it had intended to go. Later J. Cholnoky also made a journey to China with special hydrographic aims.

G. Weinek, an astronomer and professor, made observations on Isle Kerquelen, as a member and deputy leader of the German Venus expedition of 1874, concerning the transit of Venus, and published the result of his travels. T. Posewitx, who was in the service of the Dutch Government on the islands of eastern India as a military surgeon from 1879 to 1884, published a scientific work on the same. Louis Biró traveled in New Guinea to make natural history and ethnographical studies; with the results of his travel he has enriched the National Museum. Stephen Kakas de Zalánkemen, a statesman, was sent as an envoy in 1602 to the Persian court by the Emperor Rudolph to make an alliance of defense and defiance with Persia against the Turk. During his travels he died at the town of Lahidsa, in Persia, on October 25, 1603. His work called "Her Persicum" was published in several languages. A very unsettled and adventurous life was that of Count Maurice Benyovszky, who at the close of the eighteenth century traveled through Japan, Formosa, and Macao. In Madagascar he founded the settlement of Louisbourg and several forts, and in Madagascar he is buried. Doctor Kepes was a member of the Austro-Hungarian north pole expedition of 1873–74, which was led by Payer and Weyprecht. In 1862–1864 there traveled in Africa, as wife of S. Baker, an explorer, a lady of Hungarian extraction, from Budapest, who twice saved her husband's life. Count Samuel Teleki has also had considerable success in

Africa. From 1886 to 1888 he traveled through the districts of Kilimandjaro and Kinia, and it was he that discovered the two lakes which bear the names of Rudolph and Stefania.

Everybody knows the name of L. Magyar, who, after travels in India and America, made famous journeys of discovery in southwestern Africa, where he died as a settler. Scientific explorations were pursued for a long time in America by John Xantus, who collected natural-history and ethnographical objects for the Smithsonian Institution, too. The Government of the United States intrusted him with the exploration of the southern part of California and with the management of a scientific expedition to the Sierra Madre. He presented a large collection to the Hungarian Ethnographical Museum. My fellow-president, Béla Gerster, who prepared the plans for the intersection of the Corinthian Isthmus and built the Corinthian Canal, in 1876 was a member of the international expedition sent out under Wyse to explore the Panama straits, and was intrusted with the surveying of the upper Paya and Cue district. I have made a very short résumé of the work of these Hungarian countrymen of mine, who occupy no mean place in the history of explorations and discoveries and have rendered services to international science. This is only a trifling part of that long list, which can be found in a work by Szamota published in 1892 and entitled "Old Hungarian Travelers."

But I will not trifle with your patience, and so will not spin out longer the thread of my lecture. I thank you for the kindness you have shown in granting my lecture a place in such a distinguished international gathering; I thank you, too, for the attention with which you so kindly listened to the same. The object of my lecture was to direct attention to that serious activity which the small Hungarian State, in union with the other large States, has hitherto displayed in the field of geographical science. If our past efforts are received with approval, this fact will serve us Hungarians as an encouragement to work shoulder to shoulder with you in the future, too, in the furtherance of science, which is the parent of intellectual enlightenment and liberty, our ideal.

AN APPRECIATION OF FRIEDRICH RATZEL

By MARTHA KRUG GENTHE, Hartford, Conn.

Before entering upon this morning's business it behooves us to devote a few minutes of remembrance to one in whom we all recognized one of the great masters of our science, and whose death has come as a personal loss to many a member of this congress. On the 9th of August an untimely death ended the career of Friedrich Ratzel, professor of geography at the University of Leipzig, the third of the three great R.'s in the history of modern geography—Ritter, Richthofen, Ratzel.

He was born to be a geographer, although circumstances at first did not seem to favor this vocation. Even when a mere boy he read with ardent interest the records of explorers in distant lands, and while serving his apprenticeship as a drug clerk in a little country town he prepared for the examination that was to fit him for admission to the university. Already more than 20 years old, he abandoned what his parents and friends considered a safe establishment for life in order to become a student. He started with zoology, in which he also took his doctor's degree, and a series of zoological essays which he published at that time brought him an offer as traveling correspondent for the Cologne Gazette. The years of travel in southern Europe which followed revealed to him that it was not zoology which attracted him most, and having been called home by the Franco-German war, and come back decorated with the cross of iron, he made the second and final change in his life; he went to Munich to become a student again, but this time of geology and geography. Setting out on new travels, now as a geographer, he spent the following three years in the United States, Mexico, and Cuba. When he then came back it was to stay. He settled down in Munich, where soon a professorship of geography was ready for him at the Institute of Technology of that city, and left there only for the chair at Leipzig, which he held until his death.

It is from those two cities that he sent forth the publications which made him one of the pathfinders of modern geography. The two volumes of Anthropography, together with the famous Ethnology—

which embodies, so to speak, the raw material used in the anthropogeographic work—can be called the product of the years spent at Munich. There, under the influence of Zittel and Moritz Wagner, the originator of the theory of migration, the attention of the former zoologist was first definitely attracted to the biological side of geography—to the condition of man as an inhabitant of the globe and the influence exerted upon him by his environment. Anthropography is the story of our race viewed in the light of geography.

The Political Geography, together with minor publications leading up to and culminating in it, is the product of the Leipzig atmosphere, of the intercourse with Lamprecht, Bücher, and other modern historians and sociologists. In this book the geography of the race has been developed into the geography of the state. It is no longer the geographic conditionality of a man pure and simple; not his fate as a race on the globe like other races. It is the geography of man as a ζῶον πολιτικόν, a political being, a being able to form states. The state, according to Ratzel, is an organism; it is a geographical organism in that is closely bound to the soil, that its existence depends upon the greater or lesser degree in which it takes hold of the soil—no soil, no state. As such geographic organisms states can be measured, observed, described, just like botanical or zoological organisms. In this organic treatment of the problems of the state consists the scientific work in political geography; it is the application of geography to politics, as anthropography has been called the application of geography to history.

In the second edition the scope of political geography was expanded already into a Geography of the State, of Commerce, and of War, and the author aimed still further. A General Geography of Life, a biography in the widest conception of the word, was the work which ought to have embodied the final results of this life spent in restless labor. It will never be written now. We may anticipate what it might have been from his last and most comprehensive work, Earth and Life, a general geography, presenting his conception of the whole of our science, and now his most precious legacy to his pupils. This book more than any other shows the many-sidedness of the great scholar, whom the ardent devotion to his special field of research never led to the underestimation of other lines of work, but who always preserved a harmonious, well-balanced conception of the respective values of the various branches of geography. He was as far from the exaggerations of Ritter's disciples, who very nearly made geography a mere appendix to history, as he was from that one-sided conception held by some modern scholars to whom geography is only a branch of the natural sciences. Whether the search for the North Pole or Chinese immigration, whether the snowfall in the

mountains of Germany or the nebular hypothesis, nothing geographical was alien to him. He has written the best small monograph of Germany and the best large monograph of the United States ever published in Europe. He took an active interest in public life and public education, and the humble school-teacher who had to knock the boundaries of the States into his pupils' heads found just as hearty a welcome with him as the almighty minister who could upset them by a stroke of his pen.

Does it need to be mentioned what an inspiring teacher such a man must have been to mature students? All of us who were privileged to be admitted into his presence feel that we owe him part of the best which makes our lives worth living, our work worth working. It was not always easy for a newcomer to appreciate him. He was not a teacher for beginners, and many a young fledging has been heard to say that he did not see what people found in Ratzel's lectures. Even one who had served his apprenticeship in geography would sometimes require a little while to get hold of his methods and to understand the spirit of his work. But this difficulty once overcome, his lectures were a treat to which one looked forward with pleasant expectancy from day to day. Nor was his influence limited to lectures alone. In the geographical seminar of the university he built up an institution where the student was to have his geographical home and where he could at any time enjoy the privilege of personal contact with the master. However overcrowded with work, he was always willing to advise and help, and rich and poor, young and old, German and foreign, man and woman, were all the same to him as soon as he found they were serious workers. It made him happy to share with them the treasures of his knowledge and his experience: he "wished to be more to his students than a walking text-book or collection of exercises." Even when you left the university this kindly interest still followed you and remained the same however high he rose on the ladder of scientific fame and official honor. "For my students I remain the professor," he said to one of them in reply to congratulations on receiving the rank of Geheimrat.

On the 30th of August of this year he was to have celebrated his sixtieth birthday, and his students far and near were busy preparing a gift that should make the day forever memorable in the history of geography by the publication in his honor of the best products of their industry, which were to show how the seeds sown by him had sprouted and grown. The homage to the living has been changed into the tribute to the dead, but his memory will not die with those who called him their beloved master, and it will live in the history of science as long as the human intellect shall try to find the solution of the great problem of the universe.

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